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Activities and Results of the 1996 Joint Service Integrated Diagnostics Workshop

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PREFACE

This paper was prepared by the Institute for Defense Analyses (IDA) for the Office of the Director, Industrial Capabilities and Assessments, Under Secretary of Defense for Acquisition and Technology, under the task entitled Integrated Diagnostics and Improved Affordability for Weapon Support Systems. It fulfills the following task objective: "In conjunction with an industry review forum, identify opportunities and develop concepts and demonstration implementation approaches for improving integrated diagnostics." This paper documents the activities and results of the Joint Service Integrated Diagnostics Workshop held at IDA on August 8, 1996, and provides an IDA study team's analyses of the results.

The following IDA research staff members were reviewers of this document: Dr. Alfred E. Brenner, Dr. Dennis W. Fife, Dr. Richard J. Ivanetich, Mr. Terry Mayfield, Mr. Michael S. Nash, and Dr. Danny L. Reed.

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EXECUTIVE SUMMARY

On August 8, 1996, the Institute for Defense Analyses (IDA) hosted a Joint Service Integrated Diagnostics Workshop under the auspices of the Office of the Director, Industrial Capabilities and Assessments, Under Secretary of Defense for Acquisition and Technology. The participants were from U.S. government organizations and included representatives from the technology development, acquisition, and support functional areas of the Services (Army, Air Force, Navy, and Marines). This paper documents the activities and results of the workshop and provides an IDA study team's independent analyses of the workshop results.

Background

A necessary step in the maintenance and repair process of weapon systems is investigating the nature or cause of hardware and software anomalies inhibiting normal operation. *Integrated diagnostics* represents a systems approach where integrating diagnostic elements creates a total diagnostic capability that outperforms individual support and maintenance tools operating alone. While specific benefits of robust integrated diagnostics capabilities will vary by application, reported benefits include greater operational readiness, improved systems confidence, improved availability, reduced maintenance work loads, and reduced life-cycle costs.

While some progress has been made in integrating diagnostic elements, extensive integration into systems, once fielded or as they become legacy systems, has often been difficult to justify. To begin with, the development of diagnostic elements takes a long time for new weapon systems and often occurs near the end of the weapon development period. Rarely are integrated diagnostic improvements to legacy systems justified as stand-alone initiatives. Instead, legacy system diagnostic improvements—when they do occur—tend to be secondary benefits of system modifications originally made to improve performance. Also the degree and types of diagnostic element integration are severely limited by infrastructures already put in place for legacy systems.

Approach

Workshop. In preparation for the workshop, IDA asked would-be attendees to submit descriptions of test and diagnostics problems and their proposed solutions. At the workshop,

participants were divided into two working groups: Legacy Systems and Cross-Cutting. The Legacy Systems Working Group was asked to identify test and diagnostics problems and potential solutions for legacy systems; the Cross-Cutting Working Group was asked to identify test and diagnostics problems that crossed domains as well as potential solutions to these problems.

IDA analysis of workshop results. The IDA study team created a set of five questions and used them to organize and assess issues, problems, solutions, and opportunities identified during workshop activities. The team's findings, discussed in the next section, were based on the team's evaluation of the answers to these questions against (1) results of the two working groups and descriptions of problems and (2) potential solutions submitted by attendees in preparation for the workshop. The IDA study team also furnished observations on the workshop activities from the perspectives of the team members, based on their individual experiences and knowledge.

Findings

Are there critical test and diagnostics issues or problems limiting legacy system diagnostic performance and the ability to meet new and future diagnostic demands? Diagnostic performance of defense systems is not commensurate with state-of-the-art attainable performance. Performance limitations constitute critical problems that result in increased life cycle costs, decreased systems availability, and increased support and maintenance burdens.

Are the pervasive test and diagnostics issues differentiated solely by the legacy systems diagnostic performance issues, or are they also applicable to the new and future system issues that cross-cut domains? Issues surrounding the test and diagnostics problems appear pervasive and similar for both legacy systems and systems that cut across domains.

What are the underlying thrusts or new directions that synthesize proposed solutions of the pre-workshop and workshop working groups? Thrusts underlying proposed workshop solutions tend toward two principal areas: increasing awareness of integrated diagnostics benefits and increasing data accuracy.

What are the technology issues needing attention to achieve proposed solutions and maximize the use of existing technology opportunities? Potential integrated diagnostics solutions are not limited by current, state-of-the-art, nor off-the-shelf technologies.

Is infrastructure of integrated diagnostics a key element in proposed solutions? The most significant condition limiting improvements is an infrastructure that lacks of an open or common architecture.

Observations

Lack of definition. The study team observed that although the workshop participants recognized significant benefits of integrated diagnostics, they lacked a clear consensus as to its definition. In the opinion of the IDA study team, an open system architecture approach for integrated diagnostics would resolve many of the definitional concerns cited at this workshop.

Open system architecture. Integrated diagnostics implementations are best achieved by reducing the use of diagnostic element interfaces that are implementation unique and increasing the use of interface standards that are open, well defined, non-proprietary, and commonly accepted. An open system architecture would give the Department of Defense (DOD) opportunities for competitive solutions, reduced implementation costs, improved system design and support flexibility, and incremental technology improvements.

Data as diagnostics information. For integrated diagnostics to be beneficial and effective, data must be turned into information that is accurate, timely, reliable, and, most importantly, *useful* in helping to predict and eliminate or reduce field repair requirements. The study team recognized a potential for open architectures to improve information usefulness by applying modularized diagnostic elements, enhancing timely data exchange, and adding flexible analysis capabilities.

Recommendation

The underlying problem of all the individual problems discussed by the participants was the lack of a well-defined framework for all the diagnostics problems. Establishing an open system architecture was the one improvement initiative with the most overall benefits. The team, therefore, recommended that DOD should conduct a two-phase study and demonstration activity to establish an integrated diagnostics open system architecture.

CHAPTER 1. INTRODUCTION

1.1 Purpose

The Institute for Defense Analyses (IDA) conducted a Joint Service Integrated Diagnostics Workshop on August 8, 1996, under the auspices of the Office of the Director, Industrial Capabilities and Assessments, Under Secretary of Defense for Acquisition and Technology. Participants were from government organizations and included representatives from the technology development, acquisition, and support functional areas of the Services (Army, Air Force, Navy, and Marines). The initial objectives of the workshop were threefold:

- Increase the awareness of the benefits of integrated diagnostics applications.
- Identify weapon system support problems where a better integrated diagnostic approach can be applied.
- Propose integrated diagnostics opportunities that cross-cut domains.[1]

During the course of the workshop, a fourth objective was identified: to begin discussions on the opportunities of applying open or non-proprietary architectures to integrated diagnostics. Participants in this workshop were divided into two working groups. The Legacy Systems Working Group was asked to identify legacy system test and diagnostics problems and potential solutions. The Cross-Cutting Working Group was asked to identify test and diagnostics problems that crossed domains as well as potential solutions to these problems. Both working groups focused on achieving all four of the objectives.

The purpose of this paper is to document workshop activity results and present an IDA study team's analyses of the workshop results.

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[1] In the context of the workshop, the term *domain* was intended to address weapon systems and their capabilities that span from legacy systems to new and proposed weapon system designs, and included all inter-Service weapon system applications across operational boundaries such as those found in air, land, and sea system applications.

1.2 Background

On October 11, 1988, the National Security Industrial Association (NSIA) and representatives from the Office of the Secretary of Defense sponsored executive round-table meetings [NSIA 89] on implementing integrated diagnostics. Examples of integrated diagnostic elements included built-in test, automatic test systems, and data collection and analysis systems. The NSIA suggested that the Department of Defense (DOD) should improve maintenance through diagnostics-development discipline and integrating diagnostics elements. The results of these meetings were presented by the NSIA to the Under Secretary of Defense for Acquisition on April 14, 1989. Various studies and initiatives since that time have clearly shown that total diagnostic performance is enhanced by the synergistic interaction of diagnostic elements [Brown 90a, 90b; TRW 96a, 96b].

There are several descriptions and definitions of integrated diagnostics in use by NSIA, the Institute of Electrical and Electronics Engineers (IEEE), and various Services and government agencies in the defense community. The IDA study team found that the most comprehensive definition was put forward by William Keiner [Keiner 90] who defined integrated diagnostics as "... a structured process which maximizes the effectiveness of diagnostics by integrating the individual diagnostic elements of testability, automatic testing, manual testing, training, maintenance aiding, and technical information."

The development of diagnostic elements takes a long time for new weapon systems and occurs near the end of the weapon development period. While there have been some improvements, extensive integration of diagnostic elements into systems once fielded, or as they become legacy systems, has often been very difficult to justify. Rarely are diagnostic improvements justified as stand-alone initiatives. Instead, legacy system diagnostic improvements, when they do occur, tend to be secondary benefits of system modifications justified on the basis of performance enhancements. The degree and types of diagnostic element integration are severely limited by infrastructures already put in place for legacy systems.

Integrated diagnostics also provides an effective approach for the prediction, detection, and isolation of faulty conditions. Integrated diagnostics helps compensate for diagnostic difficulties associated with increasing subsystem complexity and interdependency. The consequences of poor diagnostic performance can be very costly, and inaccurate diagnosis can lead to mission failures, reduced readiness, and low system availability. Examples of these problems included (1) fault isolation ambiguities resulting in excess subsystem removals, (2) a higher-than-required maintenance and repair work load, (3) an increased demand in spare parts, and

(4) a greater "logistics tail"[2] in terms of increases in support and test equipment requirements, support and maintenance people, and transportation needs.

Integrated diagnostics represents a systems approach to investigating the nature or cause of hardware and software anomalies inhibiting normal operation, a necessary step in the maintenance and repair process. Logistics capabilities are enhanced by integrating diagnostic elements. Integrating diagnostic elements creates a total diagnostic capability that exceeds the upper performance limits of individual support and maintenance tools operating alone. While the specific benefits of robust integrated diagnostics capabilities will vary by application, reported benefits include the following:

- Greater operational and mission readiness
- Improved systems confidence
- Improved systems availability
- Reduced depot and organizational maintenance work loads
- Reduced life-cycle costs

1.3 Approach

In preparation for the workshop, attendees were asked to submit descriptions of test and diagnostics problems as well as proposed solutions to these problems. In the working group sessions, participants also identified test and diagnostics problems and potential solutions. The IDA study team's first step was to consolidate the lists of problems and solutions into a set of tables for easier reference and analyses. The results of the workshop, as summarized in these tables, represented the open dialogue over very broad topic areas and the viewpoints of other Service and DOD personnel from disparate organizational and functional assignments.

Given the range of topic areas and viewpoints, the IDA study team set out to identify the common threads or issues found in these tables. The IDA approach to the analyses of the workshop minutes and discussion was to provide a general assessment of issues and opportunities tending to be pervasive throughout the lists of problems and solutions. The IDA study team developed and addressed the following questions:

- Are there critical test and diagnostics issues or problems limiting legacy system diagnostic performance and the ability to meet new and future diagnostic demands?

[2] The "logistics tail" is the chain of logistics support that goes from the battlefield back to the continental United States maintenance depots, factories, and contractor support personnel.

- Are the pervasive test and diagnostics issues differentiated solely by the legacy systems diagnostic performance issues, or are they also applicable to the new and future system issues that cross-cut domains?
- What are the underlying thrusts or new directions that synthesize proposed solutions of the pre-workshop and workshop working groups?
- What are the technology issues needing attention to achieve proposed solutions and maximize the use of existing technology opportunities?
- Is infrastructure of integrated diagnostics a key element in proposed solutions?

The first three questions were designed to look for issues and opportunities that appeared to be critical, pervasive, and underlying in nature. The fourth question, based on the major role that technology evolution and advances have played in defense systems development, addressed whether technology might also play a role in solving perceived problems. The fifth question explored what role infrastructure appears to play in integrating diagnostic elements across the proposed solutions. The answers to these questions, based on the problems and solutions resulting from the workshop activities, appear in Chapter 3.

1.4 Organization

Chapter 2 contains summary tables and discussions of workshop activities. Created by the IDA study team, these tables were used by the study team as the basis for the team's findings.

Chapter 3 contains the IDA study team's analyses of the discussions, problems, and solutions raised by the two working groups in separate and combined sessions. The analyses are organized around the five questions identified previously in Section 1.3. Chapter 3 also includes the IDA study team's own observations of the workshop. The team's original intent was to isolate critical integrated diagnostics issues and conditions influencing military systems acquisition, maintenance, support, and repair, and to coordinate the observations with all workshop participants and their respective organizations about these issues and conditions. This was not feasible because of time constraints; therefore, these observations represent only the IDA study team's perspective and may not reflect a DOD-wide position. Finally, the IDA study team offers a single recommendation based on the key integrated diagnostics improvements or activities that would have the greatest potential of broadly enhancing DoD weapons systems maintenance and support capabilities.

Appendix A contains the minutes[3] of the sessions of the two working groups, focusing on test and diagnostics problems in legacy systems and those problems that cut across domains, as well as possible solutions. Appendices B through H are reproductions of the briefings given at the workshop. A list of references and a list of acronyms are provided at the end of the document.

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[3] The minutes have been approved by the chairs of the two working groups and distributed to workshop participants prior to the publication of this IDA paper. Therefore, no editorial changes have been made to Appendix A.

CHAPTER 2. SUMMARY OF WORKSHOP ACTIVITIES

The combination of activities leading up to the 1996 Joint Service Integrated Diagnostics Workshop and the sessions conducted by the two working groups provided three relatively independent views of test and diagnostics problems and potential solutions. The problems and solutions are summarized in tables created by the IDA study team and are presented in the following sections.

2.1 Pre-Workshop Descriptions of Integrated Diagnostics Problems and Solutions

In preparation for the 1996 Joint Service Integrated Diagnostics Workshop, attendees were asked to submit descriptions of test and diagnostics problems, as well as proposed solutions to these problems. The IDA study team used the following approach to organize and summarize the submitted descriptions:

- General categories were selected to match descriptions.
- Ideas and concepts were reduced to general thoughts marked by bullets.
- Screening of details was limited to simplifying presentations.
- No weight was assigned to presentation order.

Seven general categories were selected and summary descriptions of the results are presented in Table 1.

Table 1. Problems and Solutions Submitted Prior to Workshop

General Category	Problems	Proposed Solutions
General Topics	• Global (-illities, manpower, costs, etc.) • Confusion about integrated diagnostics process/ practices (capabilities, engineering, variety of testing approaches) • Tenuous links to quality & process improvements	• Education • Exposure to successes • Focus on total quality as integral element of integrated diagnostics • New integrated diagnostics process guides/ manual

Table 1. Problems and Solutions Submitted Prior to Workshop (Continued)

General Category	Problems	Proposed Solutions
Diagnostic Performance	• Global (RTOK/CND, excessive maintenance, etc.) • Insufficient embedded testing capabilities • Fault isolation ambiguities • Poor isolation/duplication of intermittent faults • Poor software anomaly identification/isolation • Limited prognostic capabilities • Limited analysis capabilities for multiple failures	• Embedded and distributed test and maintenance buses • Advanced diagnostic sensors • Data fusion across and among diagnostic elements • Focus on development tools and support environment
Interfaces & Architectures	• Point solutions, inflexible to change or reuse • Costly to redevelop different solution to same generic problem • No consistent data types nor common means of accessing data • No common legacy system electronic interfaces • Proliferation of equipment, aids, tools, etc.	• Provide interface-based requirements for transparency & interchangeability • Establish data access standards & common approaches (buses, protocols, formats, etc.) • Implement open architecture for all diagnostic elements • Provide remote services links ("help desks") • Develop tool suite devoted to integrated diagnostics tasks
Data Exchange & Presentation	• Data security & integrity (for accident & threat) • Accurate, detailed, real-time configuration status • Electronic display limitations (size, "washout"[a]) • Common/standard approaches for automated data capture • Data entry limitations	• Self-checking and self-correcting data media • Alternate input/output (video, voice, etc.) • Capitalize on Internet & multimedia • Exploit electronic memory & search techniques • Remote data access for configuration, update, logs • Seamless communications nets
Training	• Growing system complexity • Variety/proliferation of system types & configurations • Integrated & interdependent systems • Support tool complexity (needs own training)	• Real-time expert guidance (analysis & artificial intelligence) • Remote diagnostican & operator support • Easy-to-use tools & aids • Tools that learn with operators
Technology Transfer	• Principles & methods not totally understood • Available technology not being applied • Improvements not reaching legacy systems • Improvement needs not substantiated, supported, or funded	• Build support through demonstrations

Table 1. Problems and Solutions Submitted Prior to Workshop (Continued)

General Category	Problems	Proposed Solutions
Business Practices	• Need focal points for integrated diagnostics • Services/programs focus on individual needs versus common benefits • Contractor interests follow funding (infrequently aligns with integrated diagnostics goals) • DOD lags commercial technology/business practices • Difficult to keep up with all/new solutions	• Establish linked integrated diagnostics offices in Services • Establish integrated diagnostics R&D facility & dedicated dollars • Establish system of virtual integrated diagnostics offices with links across DOD lines • Conduct demonstrations (get things started) • Establish Joint Office on Integrated diagnostics to keep up with technology • Take advantage of existing capabilities

a. "Washout" refers to contrast problems (e.g., too bright, glare) on the display.

2.2 Legacy Systems Working Group

In the context of the Workshop, the term *legacy* was used to represent *existing* systems. From this perspective, the Legacy Systems Working Group was tasked to identify legacy system test and diagnostics problems and potential solutions. Table 2 summarizes the results of this working group. More detailed discussions are contained in the Workshop minutes in Appendix A.

Table 2. Legacy Systems - Problems and Solutions

Problems	Proposed Solutions
Test data and diagnostic interfaces are not standard at any level (functional, system, platform, or service).	— No consensus solutions identified —
Diagnostic capability is hampered by poor configuration management of design and test documentation over life cycle.[a]	— No consensus solutions identified —
Non-standard data collection, transfer, and storage, and validity of operational, maintenance, & configuration data are questionable.	— No consensus solutions identified —
Need for on-the-job training is increasing, while number of maintainers and amount of formal training received are decreasing.	Conduct demonstrations to show where technology may compensate for formal classroom training deficiencies.
Processes for linking diagnostic improvements, acquisition streamlining, and commercial off-the-shelf products/parts are not well defined.	Recommended processes should be developed and included into the new DOD or Service acquisition deskbooks.

Table 2. Legacy Systems - Problems and Solutions (Continued)

Problems	Proposed Solutions
Diagnostic improvements are not occurring because maintenance equipment capability and test methods are not being tracked against actual field procedures and failures.	Improve data collection and tracking and utilize to implement diagnostic improvements.
Policy should not dictate that all solutions be "general" or "standard." Both are good for some applications.	Capabilities should be made available to permit demonstration and trading-off of general versus point solutions.
An integrated diagnostics clearing house does not exist—integrated diagnostics information sharing and transfer are limited.	A joint-Service group should be established with responsibility for drafting integrated diagnostics strategic plan.

a. Problems frequently start in acquisition when capabilities are not bought or else not bought in usable format.

2.3 Cross-Cutting Working Group

The Cross-Cutting Working Group was tasked to identify test and diagnostics problems that cut across domains as well as potential solutions to these problems. In the context of the workshop, the term *domain* was intended to address systems and their capabilities that span from legacy systems to new and proposed weapon system designs, and included all inter-Service weapon system applications across operational boundaries such as those found in air, land, and sea system applications. Table 3 briefly summarizes the Cross-Cutting Working Group results. More detailed discussions are contained in the workshop minutes in Appendix A.

Table 3. Cross-Cutting Domains - Problems and Solutions

Problems	Proposed Solutions
Lack of common integrated diagnostics • Definitions • Functional architectures & interfaces • Measures of effectiveness	Establish a U.S. government/industry consortium to resolve.
Lack of common processes for instituting integrated diagnostics over system life cycles	— No consensus solutions identified —
Personal and organizational objectives can reduce accuracy of field maintenance data.	Remove subjectivity by increasing automated reporting.
Uncommon and un-automated data collection schemes impede integration of diagnostic information.	— No consensus solutions identified —

Table 3. Cross-Cutting Domains - Problems and Solutions (Continued)

Problems	Proposed Solutions
Processes for integrating diagnostic data and capabilities are not well defined nor under organizational control or sponsorship.	— No consensus solutions identified —
Analog built-in-test (BIT) capabilities lack common protocols, standards, or techniques.	Identify BIT formats and address trade-offs of on-board vs. off-line testing.[a]

a. Presented as an unfunded study under Task #11 of the DOD ATS Executive Agent R&D Project, and addressed in more detail in Appendix H of this paper.

CHAPTER 3. ANALYSES

The analyses in this chapter are based on the IDA study team's assessment of the answers to the five questions identified in the approach section of Chapter 1. Each question is addressed in Section 3.1, with the finding followed by the IDA study team's discussion. Section 3.2 presents the IDA study team's observations of the workshop, and a recommendation is given in Section 3.3.

3.1 Findings

Are there critical test and diagnostics issues or problems limiting legacy system diagnostic performance and the ability to meet new and future diagnostic demands?

> **Finding 1.** Diagnostic performance of defense systems is not commensurate with state-of-the-art attainable performance. The resulting performance limitations constitute critical problems causing increased life cycle costs, decreased systems availability, and increased support and maintenance burdens.

The IDA study team defined a test or diagnostics problem as a *condition* that limited weapon system capability or performance. For the purpose of this analysis, problems were considered critical when current practices for identifying and correcting a problem were more costly than alternative practices benefiting from the integration of diagnostic elements.

Evidence that critical test and diagnostic limitations exist was provided by the vast range and large numbers of problems presented by the workshop attendees (summarized in Tables 1, 2, and 3 in Chapter 2).

However, verifying that a limiting condition constitutes a critical problem is much harder to accomplish with certainty. Anecdotal evidence of cost benefits derived from specific integrated diagnostics improvements was presented both during the introductory briefings and by attendees during the working group discussions. The source of benefits cited most frequently tended to be the elimination of duplicative efforts (e.g., re-developing, re-testing, re-working).

The IDA study team observed that over the past years there have been no other suitable measurement mechanisms introduced, short of conducting system-level integrated diagnostic demonstration programs. Demonstration programs were cited as tools that may be used by DOD to verify the specific benefits of adopting integrated diagnostics improvements in both legacy and future weapon systems.

The IDA study team found that critical test and diagnostics problems diminished weapon system capabilities or performance and increased the need for additional off-line testing, formal and on-the-job personnel training, the necessary development of additional technical information, etc. This finding was based on (1) the compelling arguments presented by attendees, (2) the sheer number of similar conditions that might benefit from common actions, and (3) the anecdotal evidence of cost benefits (in terms of both dollars and resources) realized in past integrated diagnostic demonstrations [MDA 96]. These past demonstrations were initiated by DOD to increase aircraft availability by improving diagnostic accuracy while reducing maintenance man-hours.

Are the pervasive test and diagnostics issues differentiated solely by the legacy systems diagnostic performance issues, or are they also applicable to the new and future system issues that cross-cut domains?

> **Finding 2.** The pervasive mix of test and diagnostics issues tends to be similar for legacy systems and for systems that cross-cut domains.

For this part of the analyses, the IDA study team looked at the similarities and differences among the issues identified during the sessions of the Legacy Systems and Cross-Cutting Working Groups.

The IDA study team chose to look for issues associated with the summarized problems and potential solutions presented in both Tables 2 and 3 in Chapter 2. This approach was selected because of the desire to assess issues that were "pervasive" across different applications. Then, recognizing a degree of overlap between summaries presented in the individual problem categories, the IDA study team drafted the following set of test and diagnostics issues. Once these issues were identified, it permitted formulation of a recommended architecture approach on how DOD can contain costs for both its legacy systems and new systems and how to improve on their diagnostic performance capabilities.

a. *Paucity of common data and diagnostic system interfaces.* The lack of common interfaces, protocols, data structures, etc., was cited throughout by both working groups. This issue was also discussed openly during the workshop sessions and reg-

ularly during introductory briefings. For example, the cross-cutting problems and solutions of the issue were highlighted as data definition differences between the Services on the Joint Advanced Strike Technology (JAST) program. In a similar vein, the legacy system nature of the issue was highlighted as data formats and protocols on the Integrated Maintenance Data System (IMDS).

b. *Quality and validity of design, documentation, and configuration data.* This issue was only cited in the Legacy Systems Working Group sessions. The IDA study team noted that a possible reason for this difference may be newer systems are doing a better job of acquiring and maintaining essential diagnostics-related documentation. Another reason may be that similar problems have not yet been identified on newer systems (e.g., not yet fielded). A third reason may be that new systems have an evolving infrastructure that may more readily accommodate and integrate diagnostic elements than does an established legacy infrastructure. However, there was insufficient information to characterize why this difference was only noted in the Legacy Systems Working Group.

c. *Non-standard data collection, transfer, storage, and meaning.* This issue was consistently cited by both working groups. No significant differences were observed by the IDA study team members. Similar to the paucity of common data and diagnostic system interfaces, this issue was cited in the JAST and IMDS introductory briefings.

d. *Training.* This issue was only cited in the Legacy Systems Working Group sessions. The IDA study team observed that a possible reason for this difference may be that newer systems are doing a better job of initial training. Another reason may be due to the fact that similar problems have not yet been identified on newer systems (e.g., not yet fielded). A third reason may be that newer systems have achieved higher levels of diagnostics element integration, and additional training for legacy systems is required to make up for the lack of integrated diagnostics tools and the information exchange across diagnostic elements. However, there was insufficient information to characterize why this difference was only noted in the Legacy Systems Working Group.

e. *Need for centralized focus and better process definition.* This issue was consistently cited by both working groups. No significant differences were observed by the IDA study team members.

f. *Accuracy of data collection and reporting.* This issue was consistently cited by both working groups. No significant differences were observed by the IDA study team members.

Two of the six test and diagnostics issues were not identified as issues in the Cross-Cutting Working Group: item *b*, Quality and validity of design, documentation, and configuration data; and item *d*, Training. The other four issues were identified by both working groups, and these issues, as stated in the discussions in both groups, were nearly identical in nature. This led to the IDA study team's finding that the pervasive issues tend to be similar for legacy systems and for systems that cross-cut domains.

What are the underlying thrusts or new directions that synthesize proposed solutions of the pre-workshop and workshop working groups?

Finding 3. The identified solutions chiefly addressed two principal areas:

- *Increasing awareness of integrated diagnostics benefits.* This solution would increase the awareness of integrated diagnostics benefits through integrated diagnostics demonstrations, groups/centers of integrated diagnostics focus, integrated diagnostics process guides, global integrated diagnostics plans, formal training, etc., all with the same general focus towards consistent integrated diagnostics definitions, standards, and measures of effectiveness.
- *Increasing data accuracy.* This solution would verify integrated diagnostics benefits and justify improvements The automation of some maintenance data collection would be a major step to improving accuracy by removing subjectivity and enhancing data exchange.

For this part of the analyses, the IDA study team characterized the proposed solutions presented by the working groups. The IDA study team looked for common links among the rationales behind each proposed solution. Two common links appeared prominent: increasing *awareness* of integrated diagnostics and increasing *data accuracy.* The approaches to accomplishing the goal of extending or increasing awareness of integrated diagnostics benefits included (1) the establishment of groups or forums with responsibilities for identifying future directions, and (2) the use of demonstrations to verify the benefits of improved diagnostics capabilities.

From the data accuracy perspective, the rationale behind the proposed solutions came from three different sources: the pre-workshop and mail-in activity, and the two independent working groups assembled during the workshop. One solution was to use better information, resulting from improved data accuracy, to verify integrated diagnostics benefits (this focus is not totally independent of the first common link: increasing awareness of integrated diagnostics). Another solution was to directly address a major contributor to data accuracy problem by removing individual and organizational subjectivity through increased automation of data collection. The third solution was to transform raw data into timely information through integrated diagnostics synthesis tools, thus providing the right information at the right time.

The IDA study team noted the absence of proposed solutions that would have addressed the lack of common interfaces, non-standard data collection and transfer schemes, and the lack of common processes for instituting integrated diagnostics. The IDA study team believes that these problem areas fall under the general category of architectures and interfaces, which are discussed in more detail in the discussion under Finding 5.

What are the technology issues needing attention to achieve proposed solutions and maximize the use of existing technology opportunities?

> **Finding 4.** Integrated diagnostics improvements are not limited by current, state-of-the-art, nor off-the-shelf technologies.

For this part of the analyses, the IDA study team set out to identify any new technologies that may be needed to achieve the proposed solutions in Tables 1, 2, and 3 in Chapter 2. The IDA study team reviewed all of the proposed solutions, and made an effort to assess whether limitations posed by currently available technology would inhibit solution implementation. With the exception of two specific categories[1] of existing and proven technologies discussed in the workshop minutes (Appendix A), the IDA study team did not believe there were any immediate limitations to implementing improved diagnostics capabilities imposed by current or available technologies.

The study team found that opportunities for improving integrated diagnostics, identified during the workshop activities, can be realized by applying current, state-of-the-art, or off-the-shelf technologies. In general, the IDA study team agreed with the statement put forward during the Cross-Cutting Working Group sessions that "Integrated diagnostics is not a technical problem—it is a political, cultural, organizational problem." However, the IDA study team's

[1] Analog built-in test (BIT) and advanced diagnostic sensors.

opinion is that future technology advances will provide further opportunities to enhance diagnostic accuracy, performance, and cross-cutting capabilities.

Is infrastructure of integrated diagnostics a key element in proposed solutions?

> **Finding 5.** The most significant condition limiting integrated diagnostics improvements is the lack of an open system architecture.

For this part of the analyses, the IDA study team reviewed and categorized the problems, submitted by both working groups, that were based on system capability to exchange information across interfaces.

The IDA study team recognized that the term *infrastructure* could have a variety of interpretations. In the context of integrated diagnostics, the IDA study team defined infrastructure to represent a collection of hardware and software elements, interfaces, policies, and processes that provide the means of implementing a support capability. In an effort to further scope the analysis, the IDA study team looked at characteristics of open system architectural interfaces for diagnostic elements, with specific emphasis on the exchange and use of data needed to support testing, diagnostics, and maintenance. The IDA study team then identified problem areas that focused on difficulties and limitations posed by data exchange practices between and across interfaces.

The type and nature of identified interface difficulties and limitations cited in both the introductory presentations and during working group sessions are listed in the following paragraphs. (Note that the pervasive nature of these difficulties and limitations was already discussed previously in the Finding 2 discussion, items *a*, *c*, and *f*.)

a. *Proliferation of data collection schemes and media.* There are no common methods, equipment, or practices for diagnostic element data capture across system and service applications.

b. *Unique diagnostic element interfaces.* There is a lack of common data interface links (hardware or software) between diagnostic element applications, leading to a proliferation of system unique solutions.

    1. Electrical interface characteristics (geometry, pin-outs, power, etc.) are unique to most weapons systems applications, and to most subsystems within these applications.

    2. Information protocols for accessing, transmitting, or servicing data across interfaces are unique for most applications.

3. Data formats and data communication approaches are unique for most applications.

c. *Limited data access.* Data storage schemes and database architectures are not responsive to integrated diagnostics needs because of slow and ineffective query capabilities, data ambiguities, and inabilities to link interdependent data records within and across databases.

d. *Inconsistent data types and definitions.* Data type, name, and definition variations by services, diagnostic elements, and weapon system applications limit commonality of diagnostic tools and inhibit information sharing.

e. *Limited common embedded and/or distributed test and maintenance busses.* Physical, functional, and protocol accesses to on-board system test and maintenance data interfaces tend to vary by specific weapon system, the subsystems installed in the weapon system, service, diagnostic elements, and product age.

f. *Limited universal data fusion and analysis schemes.* Diagnostic information processing and sharing schemes are in limited use, and prototype tool implementations (such as knowledge-based systems or model-based reasoners) tend to be limited in design to a unique product.

The proliferation of unique diagnostic interfaces, as noted in the workshop and summarized in this list, was attributed to the following list of factors identified during the workshop. The consensus of the IDA study team was that these factors play a major role in perpetuating the presence of product-unique and sometimes proprietary integrated diagnostics interfaces:

- The lack of agreed-to standards for common and reusable applications.
- The use of system-specific diagnostic elements with their own unique and/or proprietary interfaces.
- The lack of near-term incentives for a contractor or weapon system program office to compensate for increased project cost and risks by addressing common needs across applications.[2]

[2] While the working groups felt long-term life-cycle costs are typically reduced when logistics capabilities are enhanced by the interaction of individual diagnostic elements as a systems approach, most near-term implementation costs are expected to be higher, especially for the first-time development and implementation of a new common capability.

The consequences of unique and limiting interface conditions included limited data sharing, limited tool interchangeability, proliferation of unique and non-reusable diagnostic tools, and proprietary or military design-specific solutions. Therefore, open system architecture interfaces for integrated diagnostics elements were considered essential to an infrastructure characterized by growth and evolution flexibility, reusability potential, and high effectiveness attributes. Based on this short analysis, the study team found the lack of an open system architecture that includes industry standards body or commonly accepted interface specifications and standards at diagnostic element interfaces to be most significant condition limiting integrated diagnostics improvements.

3.2 Observations

This section presents observations on the workshop processes and results from the perspective of the IDA study team. The original intent was to isolate critical integrated diagnostics issues and conditions influencing military systems acquisition, maintenance, support, and repair. As it was not feasible to coordinate with all workshop participants and their respective organizations under given time constraints, the observations presented herein represent the IDA study team's perspective, based on its experiences and knowledge, and may not reflect a DOD-wide interpretation.

Definition of integrated diagnostics

> **Observation 1.** While the workshop participants recognized the significant benefits of integrating diagnostics, they lacked a clear consensus as to a definition of integrated diagnostics.

From the pre-workshop problem and solution descriptions and throughout the workshop proceedings, participants cited the need for a clear definition of integrated diagnostics. Their concerns were markedly similar to those identified previously at an Integrated Diagnostics Workshop conducted by IDA on June 21 and 22, 1989, and August 3, 1989. Differences in understanding and definitions were identified when defining "integrated diagnostics" at the 1989 workshop, as shown in the following quotation, and they remain unresolved at the more recent workshop held in 1996.

> For example, the term "Integrated Diagnostics" was used (1) to represent a structured design process that integrates all related pertinent diagnostics elements, (2) to represent an acquisition approach that develops and acquires various diagnostics elements as a package, and (3) to represent a deliverable system (or subsystem) that integrates diagnostic elements [Brown 90a].

While the IDA study team prefers the definition put forward by William Keiner [Keiner 90], it felt that the underlying premise behind integrated diagnostics is well understood even with the lack of a clear definition: that is, to improve the integration of diagnostics elements that are treated as discrete elements to be developed and contracted separately, and to foster further centralized management of independently controlled diagnostic elements.

Also apparent to the IDA study team was a general consensus at the 1996 workshop that significant benefits were achievable by adopting approaches to integrate diagnostic element capabilities and responsibilities, and that these benefits resulted from the total diagnostic capability exceeding the upper performance limits of individual diagnostic elements acting in isolation.

In the opinion of the IDA study team, an approach to solving the definitional issue is an open system architectural approach that would link together the general concerns and definitional differences highlighted in the 1989 workshop quotation. Such an open system architecture should be designed with features that facilitate the following:

- *A structured design process* to integrate all relevant diagnostics elements.
- *A performance-based acquisition approach* for the delivery of diagnostics elements as a package.
- *Mechanisms to support easy integration* (e.g., plug-and-play approaches) of subsystems that will improve diagnostics and maintenance.

If such an architecture were established and followed, many of the definitional concerns cited at this workshop, as well as others in the past, would be resolved. The next observation addresses an open system architectural concept that would meet the need to facilitate multi-Service and logistic support interoperability and to support multi-user applications such as industry and DOD, and acquisition and field users.

Open system architecture for integrating diagnostics elements

> **Observation 2.** Integrated diagnostics implementations are best achieved by reducing the use of diagnostic element interfaces that are implementation unique and increasing the use of interface standards that are open, well defined, non-proprietary, and commonly accepted.

Current legacy system support and maintenance infrastructures will remain as barriers to effective diagnostic element integration and reuse until these infrastructures move away from fixed design characteristics. Improvements will come in the move towards industry stan-

dards body or non-proprietary open system architectural interfaces and *de facto* standards defining performance (functional and physical) requirements for interconnecting diagnostics elements.

Effective implementation of integrated diagnostics requires the integration of diagnostic elements across weapon system and support infrastructures. Currently, the capability of existing infrastructures to accommodate improved diagnostic elements is poor unless the elements are uniquely designed for the specific architectural interface. The opportunities for reuse and integration of existing diagnostic elements that were designed with system-peculiar interfaces are equally poor unless the alternate application has a very similar or identical interface.

Common architectures that have an open systems approach to diagnostic element interfaces and that are widely applicable across weapon systems and support infrastructures could provide the following benefits:

- An improvement in diagnostics and maintenance support performance.
- Greater opportunity for DOD to be one of many customers in the marketplace for individual diagnostic element solutions and open the opportunity for competitive solutions from multiple contractors.
- A reduction in costs during the early part of the system's implementation phase since some of the diagnostic elements are likely to exist and should be easy to integrate.
- An increase in system design and support flexibility.
- Easier improvements in incremental technology and systems.

Turning data into diagnostics information

> **Observation 3.** For integrated diagnostics to be beneficial and effective, collected data must be turned into information that is accurate, timely, reliable, and, most importantly, *useful* in helping to predict and eliminate or reduce field repair requirements.

The need for data to be accurate, timely, and reliable was continuously cited during workshop sessions. Other desirable attributes involving integrated diagnostics data cited at the workshop included easily accessible automated capture or exchange, and minimal cost for data capture, storage, and retrieval.

Yet surprising by its omission was the requirement for data to be *predictive and useful.* The IDA study team believes this was an oversight and that workshop participants generally assumed data would be useful. However, the IDA study team observed that for data to be useful, they need to be turned into information that supports maintenance and systems repair. Therefore, useful data must include the following attributes:

- Accurately portrays a number of status conditions (e.g., fault detection, fault isolation, fault prediction, system configuration).
- Identifies preferred action strategies (e.g., corrective procedures, diagnostic approaches, reliability enhancement options).
- Assesses capabilities and identifies deficiencies (e.g., analyzes high-cost drivers, supports "what if" analyses, operating performance feedback, spares requirements).

Integration and analysis functions that turn raw data into useful information may be separate tools or capabilities incorporated within diagnostic elements. In either case, the IDA study team recognized potential benefits if this functional capability were modularized and implemented as part of an open system architecture for integrated diagnostics elements.

3.3 Recommendation

The IDA study team set out to identify key integrated diagnostics improvements or activities that would have the greatest potential of broadly enhancing DOD weapons systems maintenance and support capabilities. Although a number of improvement initiatives were postulated, the establishment of an open system architecture for integrated diagnostics singularly stood out as the IDA study team's recommendation with the greatest potential benefits. Therefore, independent of the workshop, the IDA study team recommended the following:

> **Recommendation.** DOD should conduct a two-phase study and demonstration activity to establish an integrated diagnostics open system architecture.
>
> - Phase I. Initiate a broad-based study effort to identify and characterize key diagnostic interfaces.
> - Phase II. Develop and conduct a demonstration of an open system architecture approach for integrating diagnostic elements across weapon systems and support infrastructures.

Phase I activity should identify key diagnostic interfaces, both in current use and for proposed future systems. All identified diagnostic interfaces should be fully characterized in

terms of functional and physical attributes. Interface attributes should include hardware and software details that address form, fit, function, protocols, performance boundaries, and a status of the interface specifications or standards.

Phase II activity should develop an open system architecture concept to interconnect, exchange data, and process information between diagnostic elements. The development activity should culminate in implementation of the open system architecture. The architecture should demonstrate diagnostic element integration and cross-implementation of integrated diagnostics functions on several weapons systems. Weapon systems candidates for demonstration should come from different Services, and each candidate should rely on different infrastructures for support and maintenance. Finally, the open system architecture should include features discussed previously under Observation 1.

Although this recommendation does not appear directly in the workshop minutes, the IDA study team felt that synthesis of the information provided has led directly to this recommended approach. Many of the solutions offered in Appendix A dealt with one or more aspect of an open system architecture definition, and workshop participants tended to focus on the individual aspects rather than the underlying problem: *the lack of a well-defined framework for all of the diagnostic problems.* In the minutes of the workshop (Appendix A), many of the pieces of an open system integrated diagnostics architecture were discussed while not addressing the overall consequences of a clear framework.

The Legacy Systems Working Group, for example, cited non-standard interfaces, poor configuration management, and non-standard data collection, transfer, and storage. Each of these is a symptom of a poor framework, which leads to proliferation of equipment, software, and maintenance processes that create obstacles for the training of maintenance personnel and prevent feedback of information at all levels. An open system architecture will address all of these problems. The group further cited a need for standard approaches instead of dictated solutions, which implies "open" aspects. Finally, the group requested a clearinghouse for diagnostic information. While there are benefits in all of their solutions, the complexity of the multiple approaches needs to be simplified and made available to all.

The Cross-Cutting Working Group cited a very similar set of problems and solutions. For example, a request was made to establish a government/industry consortium to resolve definitions, interfaces, and measures of effectiveness. The group also cited no common process or ill-defined processes, the mixing of personnel and organizational objectives with integrated diagnostics, and non-common, inaccurate, and incomplete data availability. There were several technology-related problems such as engine test cell data or analog built-in test, but both

groups as a whole indicated that technology was not the problem while political, cultural, and organizational difficulties were.

The team felt that each of the problems cited by the workshop participants were real, and in many cases the solutions could offer considerable savings on their own merit. However, the synergy that an open system architecture approach to integrated diagnostics could provide would far outweigh the individual gains of the specific workshop solutions.

APPENDIX A. WORKSHOP MINUTES

[**Note:** The minutes have been approved by the chairs of the two working groups and distributed to workshop participants prior to the publication of this IDA paper. Therefore, no editorial changes have been made.]

The Integrated Diagnostics Workshop was conducted by and hosted at the Institute for Defense Analyses (IDA) on 8 August 1996. IDA's participation was sponsored by the Office of the Deputy Under Secretary of Defense (Industrial Affairs and Installations), Industrial Capabilities and Assessments (IC&A) Directorate. Mr. Herb Brown, from IDA, served as workshop chairperson. The workshop agenda and introductory charts are presented in Appendix C.

A.1 INTRODUCTION & WORKSHOP OVERVIEW

Mr. Brown began the workshop by welcoming the participants (listed in Appendix C); and noting they represented a broad cross-section of technology development, acquisition, and support functional areas from the four Services (Army, Navy, Air Force, and Marine Corps) and OSD (Office of the Secretary of Defense). He provided both the administrative details and an overview of the workshop.

This was followed with an introduction to the workshop by Ms. Christine Fisher, from IC&A. She provided an overview of immediate workshop objectives and outlined a vision of potential next step/future objectives:

a. Immediate Objectives:

1. Increase awareness of benefits of integrated diagnostics applications.
2. Identify support problems where a better approach can be applied.
3. Propose cross-cutting integrated diagnostics opportunities.

b. Next Step:

1. Based on workshop, define pervasive diagnostic issues.
2. Explore open/non-proprietary architecture opportunities.

Ms. Fisher reviewed the history and progress of integrated diagnostics initiatives, emphasized technology opportunities, and discussed both the opportunities and challenges of the new acquisition environment. She next challenged the attendees by commissioning the workshop to identify perceived problems and new directions. Copies of Ms. Fisher's ID Workshop Overview are presented in Appendix D.

A.2 BACKGROUND & CURRENT ID INITIATIVES

As part of the workshop's goal to raise the level of consciousness and thinking about integrated diagnostics, Mr. Brown introduced presentations on four current initiatives directly

involving integrated diagnostics elements and capabilities. This was not an attempt to be a complete review of initiatives; instead, it was intended as a mechanism for permitting rapid transition to serious working group discussions of test and diagnostics problems and potential solutions. The following lists the initiatives/programs, the presenters, and the appendix location of the respective briefing charts:

a. Integrated Maintenance Data System (IMDS), by Maj Bryn Turner, Appendix E.

b. Integrated Diagnostics for JAST, by Mr. Gary Smith, Appendix F.

c. Aircraft Maintenance Environment, by Mr. Martin Bare, Appendix G.

d. Automatic Test Systems (ATS) R&D, by Mr. Harry McGuckin, Appendix H.

Next in the agenda, there had been scheduled a short summation of test and diagnostic problems and potential solutions that were submitted to IDA per the workshop invitation letter. Because the scheduled activities were running longer than planned at this point and because copies of submitted problems and solutions had already been sent to attendees as part of a "read-ahead" information package, Mr. Brown elected to move directly into the working-group sessions.

A.3 WORKING-GROUP SESSIONS

The structure of the working-group sessions was, by design, very flexible — the intent was to stimulate new views and new ideas. To further foster open-mindedness and creative thinking, co-chairpersons of the working-group sessions were selected from each of the four services. The attendees were asked to select one of two areas of concentration:

a. Working-Group A: Focus on Legacy Systems Problems/Solutions

b. Working-Group B: Address Cross-cutting Problems/Solutions Between Domains

Initially, each of the working-groups convened to discuss perceived problems. After about 2-hours of discussions, all of the workshop attendees were reconvened and results of this initial session were shared between both working-groups. Next, the workshop broke into the two working-groups again to address potential solutions. Finally, all of the attendees reconvened to summarize results of the second working-group session, and to open discussions among all workshop attendees. The following summarizes the results of these working-group activities by the working-group concentration areas.

A.3.1 FOCUS ON LEGACY SYSTEMS PROBLEMS/SOLUTIONS (WORKING-GROUP A)

This working-group was co-chaired by Mr. Mike Heilman of the Marine Corps and Mr. Pat Stevens of the Army. Mr. August (Gus) Scalia of IDA served as the recorder. Other participants in this group are listed:

SMSgt Greg Brewer	Mr. Vern Chance
Mr. Jeff Dean	Dr. Warren Debany
Mr. Doug DuBois	Mr. Charles Gelfenstein
TSgt Greg Greening	LtCol Harry Hamilton
Mr. Tom Ingram	Mr. Mukund Modi
Mr. Dave Paros	Mr. John Powell
Mr. Bruce Scott	Mr. Butch Sneade
Dr. Li Pi Su	

A.3.1.1 Problems Session: Legacy Systems

After an initial round of introductions by members of the legacy systems working-group, the participants began to discuss what they felt were the overall objectives of the integrated diagnostic workshop. It was agreed this would help them in deciding their approach to identifying problem statements and how they could best be tied to the overall objectives of this workshop. Group consensus was that they should shoot to develop a top 10 type list that could result in some action being taken by OSD. After a relatively brief discussion period it was agreed their purpose was to increase appreciation of the benefits of integrated diagnostics applications, to identify support problems where a better approach can be applied, and to propose cross-cutting integrated diagnostics solutions to resolve the problems.

The working-group then began to develop a list of both design data and test diagnostics problems focused to legacy systems. As the group activity began, the co-chairs mentioned that this effort should be done within some boundaries and the group agreed that they should consider all existing technology opportunities, new acquisition reform initiatives taken with the recent release of the new DoD 5000 series instructions and regulations, and the work recently done on defense acquisition deskbooks.

The first issue to be raised in the process of identifying problem one was to decide whether the term legacy system meant an information system or weapon system. It was pointed out by several members that the most recent OSD integrated diagnostic funding efforts seemed to be focused in the area of information systems and databases etc. rather than weapon plat-

forms. The group discussed some of the ID tasks that were briefed just prior to this breakout session, then agreed that both areas were appropriate. The decision was to made test the problem statements so that both weapon system diagnostic problems and the transfer ability of diagnostic information was identified. The co-chair, Pat Stevens, then took control of the group from Mr. Mike Heilman, and began the session by asking for problem ideas the group felt had resulted in not achieving either real dollar savings, lower maintenance manhours per operating hour, or the desired reliability from their products as a result of poorintegrated diagnostics.

As problems were discussed, one issue was brought up that did not make the top 10 problems list (principally because it did not directly relate to legacy systems). However, this issue is recorded here as the group felt it was important. Issue Statement: The policy level folks do not appear to be included sufficiently in the support process; and some of the current policies are not based on tested or evaluated field results, but appear to be designed to resolve global program and acquisition management issues.

The following listing presents the identified problem statements in italics and adds any clarifying or additional comments provided by the working-group in regular font type.

Problem 1: *Platforms are non-standard in hardware and software at the function levels, the system level, platform and inter-Service.* It was noted that test and diagnostic interfaces are not standardized at any level.

Problem 2: *There is a lack of design data and test documentation. There is also poor configuration management for the procured design data and test documentation when related to equipment changes (e.g., hardware, software, firmware, and paper).* Diagnostics are either not bought, or when they are bought, they are not in a useable format. Available data may not have been maintained (there is a lack of configuration control between equipment and data).

Problem 3: *Data collection, data distribution or databases are non-standard for operational, maintenance, and configuration data and the validity of the data is often questionable.*

Problem 4: *The number of maintainers and the amount of formal training they receive is decreasing. This is resulting in an increased need for field on-the-job-training (OJT), generalized training and experience level training.*

Problem 5: *Streamlining acquisition actions are not yet well-defined nor well-applied for legacy type systems in the areas of implementing COTS and commercial parts product into old systems.* There is no demonstrated process for linking diagnostics improvements for COTS and commercial parts.

Problem 6: *Maintenance equipment and methods are not being tracked with actual system failures.* The feedback loop from the field is missing.

Problem 7: *Operational availability is being documented higher than that which is really achieved and the result is that we do not get sufficient support dollars budgeted for field support.*

Problem 8: *There is a lack of low level capabilities (e.g., BIT fault grading, interfaces, etc.) to support higher level maintenance goals (e.g., time to repair, CND/RTOK, etc.)*

Problem 9: *Some general solutions do not fit for implementation on the older legacy type systems and some single point, single platform or Service solutions are indeed good solutions* (solutions do not always have to be general in nature and always be applied across the board to all the Services to be the correct answer).

Problem 10: *The department does not have an Integrated Diagnostic clearing house* (there is no central point-of-contact (POC) or group for integrated diagnostics where you can go to obtain the latest ID information). *The question is - How do we effectively transfer ID information?*

Problem 11: *There is an immediate need for common commercial equivalents and/or replacements of necessary defense interface specifications and standards (e.g. standards containing processes such as those found in MIL-STD-1814) for interface specifications, infrastructure, and functionality. They should also be referenced for guidance in the new defense acquisition deskbooks and handbooks.*

At this point, the problem identification session for the legacy system area was completed and all workshop attendees then re-convened in the main conference room to share the results of the breakout session. The results were then presented by Mr. Pat Stevens for working-group A.

A.3.1.2 Solution Session: Legacy Systems

After the joint problem session, the working-group then re-assembled to begin the second part of the workshop where they would recommend problem solutions. Participants began this session with a long discussion of the comments and questions received during the joint session problem briefings.

The group then commenced reading the problems and regrouping them based on their potential solution. The following listing summarizes how the statements were combined. For traceability, the original problem numbers are presented.

- Problem Statement 1 remained the same.
- Problem Statement 2 remained the same.
- Problem Statement 3 & 7 merged.
- Problem Statement 4 remained the same.
- Problem Statement 5 & 11 merged.
- Problem Statement 6 & 8 merged.
- Problem Statement 9 remained the same.
- Problem Statement 10 remained the same.

Problem Statement 1: *Platforms are non-standard in hardware and software at the function levels, the system level, platform and inter-Service.* It was noted that test and diagnostic interfaces are not standardized at any level.

No solution proposed.

Problem Statement 2: *There is a lack of design data and test documentation. There is also poor configuration management for the procured design data and test documentation when related to equipment changes (e.g., hardware, software, firmware, and paper).* Diagnostics are either not bought, or when they are bought, they are not in a useable format. Available data may not have been maintained (there is a lack of configuration control between equipment and data).

No solution proposed.

Problem Statement 3: *Data collection, data distribution or databases are non-standard for operational, maintenance, and configuration data and the validity of the data*

is often questionable. (Problem Statement 7:) *Operational availability is being documented higher than that which is really achieved and the result is that we do not get sufficient support dollars budgeted for field support.*

No solution proposed.

Problem Statement 4: *The number of maintainers and the amount of formal training they receive is decreasing. This is resulting in an increased need for field on-the-job-training (OJT), generalized training and experience level training.*

Recommended Solution: *New technology demonstrations should be conducted to show where technology can make up for formal classroom training deficiencies. These should be based upon the collected results of current and past demonstrations.*

Problem Statement 5: *Streamlining acquisition actions are not yet well-defined nor well-applied for legacy type systems in the areas of implementing COTS and commercial parts product into old systems.* There is no demonstrated process for linking diagnostics improvements for COTS and commercial parts. (Problem Statement 11:) *There is an immediate need for common commercial equivalents and/or replacements of necessary defense interface specifications and standards (e.g. standards containing processes such as those found in MIL-STD-1814) for interface specifications, infrastructure, and functionality. They should also be referenced for guidance in the new defense acquisition deskbooks and handbooks.*

Recommended Solution: *A list of recommended standards should be compiled, and they should be converted to commercial form and/or included into the new DoD or Service acquisition deskbooks.*

Problem Statement 6: *Maintenance equipment and methods are not being tracked with actual system failures.* The feedback loop from the field is missing. (Problem Statement 8:) *There is a lack of low level capabilities (e.g., BIT fault grading, interfaces, etc.) to support higher level maintenance goals (e.g., time to repair, CND/RTOK, etc.)*

Recommended Solution: *Improve data collection and tracking and utilize to implement diagnostic improvements.*

Problem Statement 9: *Some general solutions do not fit for implementation on the older legacy type systems and some single point, single platform or Service solutions are*

indeed good solutions (solutions do not always have to be general in nature and always be applied across the board to all the Services to be the correct answer).

Recommended Solution: *Organization and facility established to bring Integrated Diagnostic problems/solutions to (e.g. to trade-off general verses point solutions etc.)*

Problem Statement 10: *The department does not have an Integrated Diagnostic clearing house* (there is no central point-of-contact (POC) or group for integrated diagnostics where you can go to obtain the latest ID information). *The question is - How do we effectively transfer ID information?*

Recommended Solution: *Develop a draft strategic plan for Integrated Diagnostics. Start a tri-Service group on an ID level (e.g., IPT, IRB, Management Board etc.) similar to actions recently taken by DoD for Automatic Test Systems (ATS) management.* The department needs to find a method to move more pieces of what each Service is doing right and communicate that immediately to the other Services.

Late into the second work-group session Mr. Brown came in and stated that the first group was complete and asked that we rejoin the other workshop members for the summary and wrap-up session. Again, Mr. Pat Stevens from the Army presented the results of working-group A to the entire group.

A.3.2 ADDRESS CROSS-CUTTING PROBLEMS/SOLUTIONS BETWEEN DOMAINS (WORKING-GROUP B)

This working-group was co-chaired by Mr. Martin Bare of the Navy and Mr. Gary Smith of the Air Force. Dr. William R. Simpson of IDA served as the recorder. Other participants in this group are listed.

Mr. Timothy Bearse	Mr. Charles Bosco
Mr. Herb Brown	Mr. Bill Horth
Mr. Stephen Hull	Mr. Bob Johnson
Mr. David Kidd	Mr. Terry Lindemann
Mr. Harry McGuckin	MSgt Joe Oram
Mr. Jeff Riggs	Mr. Bill Ross
Mr. Howard Savage	Mr. Rickey Schippang
Mr. John Schroeder	Mr. Alex Smirnow
Maj Bryn Turner	Capt Gary Wiley

A.3.2.1 Problems Session: Cross-Cutting Domains

After a brief introduction of working-group participants, the entire group entered into lively discussions of issues. This first session was to provide statements of problems involving integrated diagnostics. This working-group considered those issues that were perceived to represent cross-cutting problems between and among domains (that is, spanned legacy to new designs and inter-service applications such as air, land, and sea).

This first working-group session was an open forum with no restrictions and not for attribution. It turned into a brainstorming session; and as a result, the many highlighted problems do not follow any specific flow. The following listing presents the identified problems in italics, and follows in regular font with the essence of extended discussions when appropriate:

Problem 1: *No central point of focus for id, duplicate expenditures because of this lack of communication.* It was noted that we have little communication between services. In fact a central focus point might help.

Problem 2: *Technical transition is not being handled well.* It was noted that some id related things are flying on the 777 but not yet available to the services.

Problem 3: *R&D not sent out into the field.* Detractors include Planning Programming and Budgeting System (PPBS), hand off from R&D to program office, rice bowls, etc.

Problem 4: *Coordinated approaches are stymied by: Rice Bowls, Funding lines, and Administrative Burdens.* There is no referee for problems among services. Often can't place a desirable technology in the right funding slots.

Problem 5: *Priorities are not the same among the services' weapons systems programs.*

Problem 6: *Rigidity of funding deadlines, sometimes on a short fuse prevents flexible use of funds for id improvements.*

Problem 7: *Inability to control funding (i.e., Congress) makes providing Id improvements difficult.*

The group then began to look to the future battle force. The following observations are pertinent and shape the further discussion of id: All battles are joint, Communications not currently compatible, and Joint logistics is needed but not currently supported.

Problem 8: *Need joint logistics approach: interchangeable parts, intertwined logistics lines, redirect logistics in transit, just in time logistics approaches, reliability centered maintenance, etc.* It was noted that the idea of autonomous logistics as presented by the JAST review is attractive, but has had some difficulty in software assigning peoples work load in the past.

Problem 9: *Need single data base for all users.*

Problem 10: *Man-in-the-loop is slow inaccurate.* A future approach will require man out-of-the-loop to the greatest extent possible. Requirement for automation here.

Problem 11: *High complexity is a driving factor which forces man out-of-the-loop.*

Problem 12: *Fault tolerance capabilities add to systems complexity.* Fault tolerance creates maintenance problems while providing performance and capability to weapon systems.

Problem 13: *Inadequate data hiding (possibly not providing everything to everybody).* Conflicts somewhat with 9, and is characterized by information glut (providing more information than can be used).

Problem 14: *Each program has a different urgency/latency which increases complexity.*

Problem 15: *ID not understood.* Education is a problem. What is ID?

Problem 16: *ID is after-the-fact.* Concurrent engineering is what is needed. System engineering should account for these factors. Problem was also stated as: *Requirements are not properly or thoroughly stated.*

Problem 17: *Need an accepted definition of ID.*

Problem 18: *We often forget that the guy in the cockpit or on the flight line have the problems.*

Problem 19: *Systems are built around history and funding rather than requirements.* There were open issues on how this will influence capabilities given what we expect to see in the future: wider range of platforms with some commonality, maintainer versed

in a wide range of weapon systems, combined MOSs (already begun in Army), and core competencies too broad.

Problem 20: *Look and feel of maintenance subsystems not same.*

Problem 21: *Functional Requirements that cross services are not well defined.*

Problem 22: *Need tools to verify that diagnostics are met.*

Problem 23: *Contracting not flexible with penalties and incentives.*

Problem 24: *No common links between/among services.* Different processing results are tied to process

Problem 25: *Non-commonality in terms.* Need common set of definitions.

Problem 26: *Cannot articulate our processes* (acquisition, development, id, etc.)

A discussion of the virtual test bench tool followed but led to no problem statement.

Problem 27: *Lack of methods for applying ID.*

Problem 28: *Contract specifications and measurements are not satisfactory.* Not all measures of effectiveness (MOEs) are measurable. Most are measurable after years in the field. We need a better handle on the quantitative aspects of ID.

Problem 29: *COTS diagnostic issues: COTS is "trust me", No data provided with COTS, NO policing of claims, and Claims are exaggerated in commercial.*

Problem 30: *Small lot size makes items expensive and hard to buy commercially.*

Problem 31: *Long development time, funding problems, etc. leads to parts obsolescence often before the weapon system is fielded.*

Problem 32: *COTS is non-stationary (rapidly evolving and changing), ID needs stability.*

Problem 33: *Kingdoms and Fiefdoms in development and sales.* PMAs, SPOs, take on survival lives of their own and drive problem solutions.

Problem 34: *State-of-the-art is moving too rapidly.*

Problem 35: *A large number of contract issues limit our ability to do anything integrated.*

Problem 36: *Too much test equipment to drag around.*

Problem 37: *Verticality between levels of maintenance not well defined.*

Problem 38: *Compartmentalized problem solutions lead to integration at the wrong levels.*

At this point the working-group had a general discussion on performance based specifications. The following concerns were observed: F^3I can't push down requirements, it tends to give up ownership of lower levels, a lack of trust frequently exists, visibility into the system is often limited.

Problem 39: *Giving up ownership in any of the levels is hard.*

Problem 40: *Not certain where level of ownership in data is needed.*

Problem 41: *No performance based requirements for diagnostics.* Some discussion of where standards and metrics interact.

The co-chairpersons cut off the general discussion at this point. They then asked the working-group to categorize these problem areas so that they might be synthesize these into problems that will be targets for solution. The chairs developed a straw-man list of topics that evolved into the list below. The group was then asked to place each of these problems (by number) in categories. Numbers were permitted to be in multiple categories. This was based on the perception any overlap might help provide emphasis or priority to the discussions and help to find patterns of groups. This resulted in the following table.

Table A-1. Synthesized Listing of Perceived Problems by General Categories

General Problem Categories	Problem Numbers that Apply
1. Contract Issues	3, 4, 5, 6, 7, 8, 13, 15, 16, 19, 21, 23, 24,28, 29, 31, 32, 33, 35, 38, 39, 40, 41
2. Common Definitions and Standards	4, 9, 15, 16, 17, 18, 19, 20, 21, 22, 25, 26, 27, 28, 36, 37, 39, 41
3. Technical Transition	2, 3, 31, 34, 36

Table A-1. Synthesized Listing of Perceived Problems by General Categories (Continued)

General Problem Categories	Problem Numbers that Apply
4. Process and Priorities	4, 5, 6, 7, 13, 15, 16, 18, 19, 22, 23, 24, 26, 27, 31, 32, 36, 37, 39, 40
5. Joint Fighting Force	3, 4, 5, 8, 18, 20, 24, 31, 39, 40
6. Program Differences	1, 5, 14, 20, 24, 30, 41
7. Automation	9, 10, 11, 12, 13, 20, 22, 34, 36, 38, 39, 40, 41
8. Complexity	9, 10, 11, 12, 14, 16, 19, 20, 31, 36, 37, 39, 40
9. Contractor Relations	3, 4, 5, 19, 23, 29, 31, 33
10. COTS	16, 19, 29, 31, 32, 34, 37
11. Training	9, 10, 11, 13, 15, 20, 36, 37, 41
12. Look and Feel	20
13. Stability versus Flexibility	6, 7, 31, 32, 34, 39, 40
14. Compartmentalization	1, 3, 4, 14, 15, 33, 37, 38
15. Ownership Levels	24, 29, 31, 39, 40
16. Organization	1, 3, 4, 6, 7, 8, 10, 11, 17, 21, 24, 31, 33, 37

Based on the results presented in Table 4, the largest number of problem statements fall in the following six categories:

- Contact issues
- Common Definitions and Standards
- Process and Priorities
- Organization
- Automation
- Complexity

At this point in time, the problems session was concluded, and all workshop attendees reconvened to share the results of the two working-groups.

A.3.2.2 Solution Session: Cross-Cutting Domains

This working-group then set about the task of identifying solutions to the problem statements. The co-chairpersons decided that the working-group should try to synthesize the 41 problem statements developed in the first session into a few basic combined problem statements. This was discussed at length. The working-group collectively decided to start with the categories of highest occurrence and synthesize problems and then propose solutions. This became a tangled web with the contract issues, common definitions and process/priorities all being intertwined at almost every turn. The difficulty appeared to be the lack of common frames of reference. This realization then led to the following synthesized problem statement below.

Problem 1: *There is no concurrence on common definitions, applicable standards, and usable MOEs for ID.*

Although there was agreement regarding this problem, almost everyone thought this was too broad to tackle. Therefore, the working-group broke this problem into smaller chunks.

Problem 1a: *There is no concurrence on common definitions.*

Problem 1b: *There is no existing agreed to sets of MOEs for ID performance.*

Problem 1c: *There is a lack of commonly agreed to functional architecture and interfaces relative to ID.*

The group agreed to these and settled on a solution given below.

Solution 1: *Establish (embellish or support) a government/industry consortium to resolve these three problems.* Further, the consortium must be joint, involve the logistics and design communities, and probably needs to be a funded entity.

Having successfully bridged this issue the group tackled processes. It was noted that there was a lack of common processes for ID. The working-group observed MIL-STD-1814 and MIL-STD-2165 provided some processes, but the MIL-STDs are not to be used and commercial standard do not address these issues. This led to the following problem statement.

Problem 2: *Lack of common processes to institute ID (Cradle to grave).*

A vigorous discussion followed, including suggestions to prepare drafts or to participate in standards groups such as IEEE or ANSI, but no solution was put forth. A suggestion was made to examine more technical issues and after some discussion, the following example

was given: *Radar Cross Section verification cannot currently be done in less than a hangar size facility.* It was soon realized that this required an R&D program in measurement science and was out of scope so that no solution was proposed. Similarly, a problem statement was developed for field data. The following was agreed to by the working group:

Problem 3: *Field data can be reported inaccurately because of non-maintenance use of the data.* (notably the reference here was to technician fitness reports)

This triggered a great deal of discussion with general agreement that this could be solved with forms of automated data collection, and the following was given as a solution.

Solution 3: *Remove subjectivity in field maintenance data by increasing automated reporting.*

This led to a new problem statement concerning field data as follows:

Problem 4: *Current data collection schemes do not support the ID process.*

An example was provided where several different jet engines used the same gas path data for test cell trims, but each had a different data unit with a different interface. There was some discussion that the general problem statement could be expanded to cover support equipment commonality with the following as a general solution: *A number of items could benefit from support equipment commonality or standards in handling aspects of support equipment.* After much discussion, this was considered out of scope for a solution statement. A great deal of energy was spent here in discussion but it was finally realized that the details of the specific application were too important to propose a general solution.

Next, the working-group noted the lack of organizations and processes specifically chartered with addressing ID problems. The problem statement was derived as follows:

Problem 5: *There is no institutionalization of the ID process.*

A variety of solutions were considered: the establishment of joint offices, more robust DoD policy, standardization issues, etc. It was finally agreed that ID should be a technical discipline not a government office or an implementation. The working-group then noted that the ID process itself is not well defined. Although a specific solution was not developed, there was general concurrence that a solution should adopt joint government/industry approaches. Remarkably, the following statement was made during the working-group discussions: "ID is not a technical problem — it is a political, cultural, organizational problem". This received some support and no refutation here, but was later taken issue with during the wrap-up.

This fostered discussions on the adequacy of built-in-test (BIT) capabilities. There was general agreement that digital BIT was a relatively mature technology. However, analog BIT implementations lag behind digital. The working-group agree that most of the difficulties centered around the lack of common, agreed-to, methods. Finally, the following problem statement was developed:

Problem 6: *Analog BIT lacks protocols, standards, and techniques (methods).*

The working-group noted that an approach to solving this problem was covered in an earlier presentation on the ATSR&D program (as one of the unfunded tasks). Therefore, the following solution was proposed:

Solution 6: *Fund ATS R&D Program Task #11* (See Mr. McGuckin's presentation.)

Having used the allotted time, the chairs summarized and then dismissed the working group so that they could rejoin the workshop for summary and wrap-up.

APPENDIX B.
WORKSHOP AGENDA AND INTRODUCTORY CHARTS

Integrated Diagnostics Workshop

8 August 1996

Integrated Diagnostics Workshop Agenda

Time	Scheduled Activity
0830 - 0900	Introduction & Workshop Overview
0900 - 1030	Background & Current ID Initiatives
	- IMDS — Maj BrynTurner
	- ASID — Mr. Gary Smith
	- AMIDD — Mr. Marty Bare
	- ATS R&D — Mr. Harry McGuckin
1030 - 1045	Summary of Submitted "Problems" & "Proposed Solutions"
1045 - 1300	Problems Working-Group Sessions — *(with working lunch)*
1300 - 1330	- Problems Working-Group Summary Presentations
1330 - 1545	Solutions Working-Group Sessions
1545 - 1615	- Solutions Working-Group Summary Presentations
1615 - 1700	Summary Discussions & Wrap-Up

8/7/96

Workshop Ground Rules

- **Relaxed Atmosphere**
- **Non-Attribution**
- **Creative Thinking and Open-Mindedness**
- **Active Participation by All Group Members**
- **Everyone's Input Has Equal Value *(We are all peers)***
- **Be Sincere *(Say what you believe, not what's expected)***

Workshop Approach

- **Introduction, Overview, and Selected Presentations**
  - Identify workshop objectives & highlight the approach
  - Break-the-ice with introductory briefings on Integrated Diagnostics related initiatives
- **Summarize Submitted Problem & Solution Descriptions**
  - Provide a flavor of the breadth & scope of problems and potential solutions
- **Conduct 2 Working Sessions:**
  - Session 1: Test and Diagnostics Problems
  - Session 2: Potential Solutions
- **Divide into 2 Working-Groups (~25 people) Per Session**
  - Group A: Focus on legacy systems problems/solutions
  - Group B: Cross-cutting problems/solutions between domains (e.g., land, sea, air, tracked vehicles)

Assignment — Problems Working-Groups
Test and Diagnostics Problems Session

- Goal: Identify Problems & Needs
- Guidance:
  - Defer problem solving & solution identification to second session
  - Look for common links or mechanism required to integrate individual diagnostic elements
- Suggested Method
  - Characterize most critical problems / needs
  - Identify cause and effect
  - Characterize barriers to the integration of diagnostic elements

Working-Groups —
Areas of Concentration & Arrangements

- **Working-Group A:**
  - Focus on Legacy Systems Problems / Solutions
  - Co-Chairmen: Mr. Mike Heilman - Marines
Mr. Pat Stevens - Army
  - Recorder: Mr. Gus Scalia
- **Working-Group B:**
  - Address Cross-Cutting Problems / Solutions Between Domains
  - Co-Chairmen: Mr. Martin Bare - Navy
Mr. Gary Smith - AF
  - Recorder: Dr. Randy Simpson

Structure is very flexible — Hope to stimulate new views and new ideas

Assignment — Solutions Working-Groups
Potential Solutions Session

- **Goal: Define Projects to Demonstrate Opportunities and Benefits of Integrated Diagnostics Improvements**
- **Guidance**
  - Look for common, cross-cutting characteristics that apply to multiple systems, and will improve diagnostics for legacy / new systems
  - Attempt to package multiple solutions in demonstration projects, so each candidate ID project will help sell itself
- **Suggested Method**
  - Assess cross-cutting nature of problems / needs
  - Propose candidate projects to illustrate benefits
  - Identify enabling technologies & implementation road-blocks
  - Propose implementation strategy

APPENDIX C.

LIST OF WORKSHOP PARTICIPANTS

INTEGRATED DIAGNOSTICS WORKSHOP

List of Invited Participants:

Note that * indicates individuals invited were able to attend the workshop on August 8, 1996.

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APPENDIX D.

INTEGRATED DIAGNOSTICS WORKSHOP OVERVIEW

Ms. Christine Fisher

Integrated Diagnostics Workshop
Overview

Ms. Christine Fisher
Industrial Capabilities and Assessments

August 8, 1996

Workshop Objectives

- **Immediate**
  - Increase awareness of benefits of Integrated Diagnostics applications
  - Identify support problems where a better approach can be applied
  - Propose cross-cutting Integrated Diagnostics opportunities
- **Next Step**
  - Based on workshop, define pervasive diagnostics issues
  - Explore open/non-proprietary architecture opportunities

Integrated Diagnostics Progress

- **Prior to Mid 1980's — Diagnostics as Discrete Elements**
  - Diagnostic elements developed and contracted separately
  - Separate maintenance organizations independently controlled diags elements
- **Mid 1980's & early 1990's — Integrated Diagnostics**
  - 1985 NSIA & OSD initiative to improve maintenance through diagnostics development discipline, integrating diagnostics elements
  - 1986: New ID Guides/tool developments funded (GMADS, IDSS)
  - FY1990 ID demonstration program element initiated ($10M/yr)
  - 1990: Major new programs apply ID (F22, Commanche)
  - 1992: new ATS policy, test information R&D and IEEE standards work
- **2000?**
  - Containing diagnostics costs for legacy systems, low volume new systems
  - Improving diagnostics flexibility and performance for fast, deep strike missions

Why Integrated Diagnostics

Logistics capabilities are enhanced by interaction of individual diagnostic elements — a systems approach

- Improve diagnostics performance of legacy systems
- Meet diagnostics demands of highly complex new and future systems
- Reduce life cycle costs with improved diagnostics performance

Existing Technology Opportunities

Diagnostics performance can be significantly improved by applying existing, proven technologies

- High speed processing power
- Electronic data exchange
- Wireless communication devices
- Open / plug & play architectures
- Satellite communications

New Acquisition Environment

Flexible acquisition approaches offer both opportunities and challenges

- Acquisitions emphasizing COTS components
- Industry maintaining configuration control longer
- Services eliminating/reducing field repair
- DoD seeking competitive support sourcing

Workshop Commission

- Workshop Products
  - Perceived problems
    - Why haven't they been fixed?
    - What is criticality?
  - New directions
    - Are there areas requiring more emphasis? Why?
    - Are there opportunities that we aren't taking advantage of? Why?
- Workshop Environment
  - Open dialogue -- integrated diagnostics is a broad topic with many viewpoints
  - Step back -- look beyond immediate, individual problems - seek underlying causes & new approaches

Back-Up Charts

BACKGROUND: What Constitutes Diagnostic Capabilities

Diagnostics: The practice of investigating the cause or nature of specific problems inhibiting normal operation

Diagnostics Capability Developed & Provided Through	Examples of Diagnostic Elements
Engineering Design -	**- Status Monitoring** **- Built-in-Test (BIT)**
Testing -	**- Automatic Test Systems (ATS)** **- Maintenance Aids**
Technical Information -	**- Technical Manuals (paper & digital)** **- Data Collection & Analysis Systems**
Personnel Skills -	**- Training** **- Knowledge Support Tools**

Workshop Approach

- **Introduction, Overview, and Selected Presentations**
  - Identify workshop objectives & highlight the approach
  - Break-the-ice with introductory briefings on Integrated Diagnostics related initiatives
- **Summarize Submitted Problem & Solution Descriptions**
  - Provide a flavor of the breadth & scope of problems and potential solutions
- **Conduct 2 Working Sessions:**
  - Session 1: Test and Diagnostics Problems
  - Session 2: Potential Solutions
- **Divide into 2 Working-Groups (~25 people) Per Session**
  - Group A: Focus on legacy systems problems/solutions
  - Group B: Cross-cutting problems/solutions between domains (e.g.., land, sea, air, tracked vehicles)

Individual Working Group Goals

- **Identify Test and Diagnostics Problems**
  - Characterize most critical problems/needs
  - Identify cause and effect
  - Characterize barriers to the integration of diagnostic elements
- **Identify Potential Solutions**
  - Assess cross-cutting nature of problems/needs
  - Identify how Integrated Diagnostics approach can help
  - Identify specific operational payoff
  - Identify enabling technologies & implementation road-blocks
  - Propose implementation strategy

Final Wrap-Up of Formal Workshop Activities

- **Reconvene & ask entire workshop to**
  - Identify most significant problems
  - Identify solutions with highest priority
  - Identify essential aspects of a successful implementation strategy

Continuing Activities

- **Keep the dialog open**
  - Continue sending to IDA descriptions of test& diagnostics problems, potential solutions, and examples of successes
  - IDA will serve as a clearing house for comments/ideas on an Open/Non-Proprietary Integrated Diagnostics Architecture

APPENDIX E.

INTEGRATED MAINTENANCE DATA SYSTEMS

Major Bryn Turner, USAF

Integrated Maintenance Data System

Integrated Diagnostics Workshop
8 Aug 96

Overview

Program Description

Target Architecture

Increments of Capability

Contract Information

Program Schedule

Program Description

IMDS is an information technology program to provide *all* persons with the maintenance related information they need to do their jobs

Initially focused on line maintainer

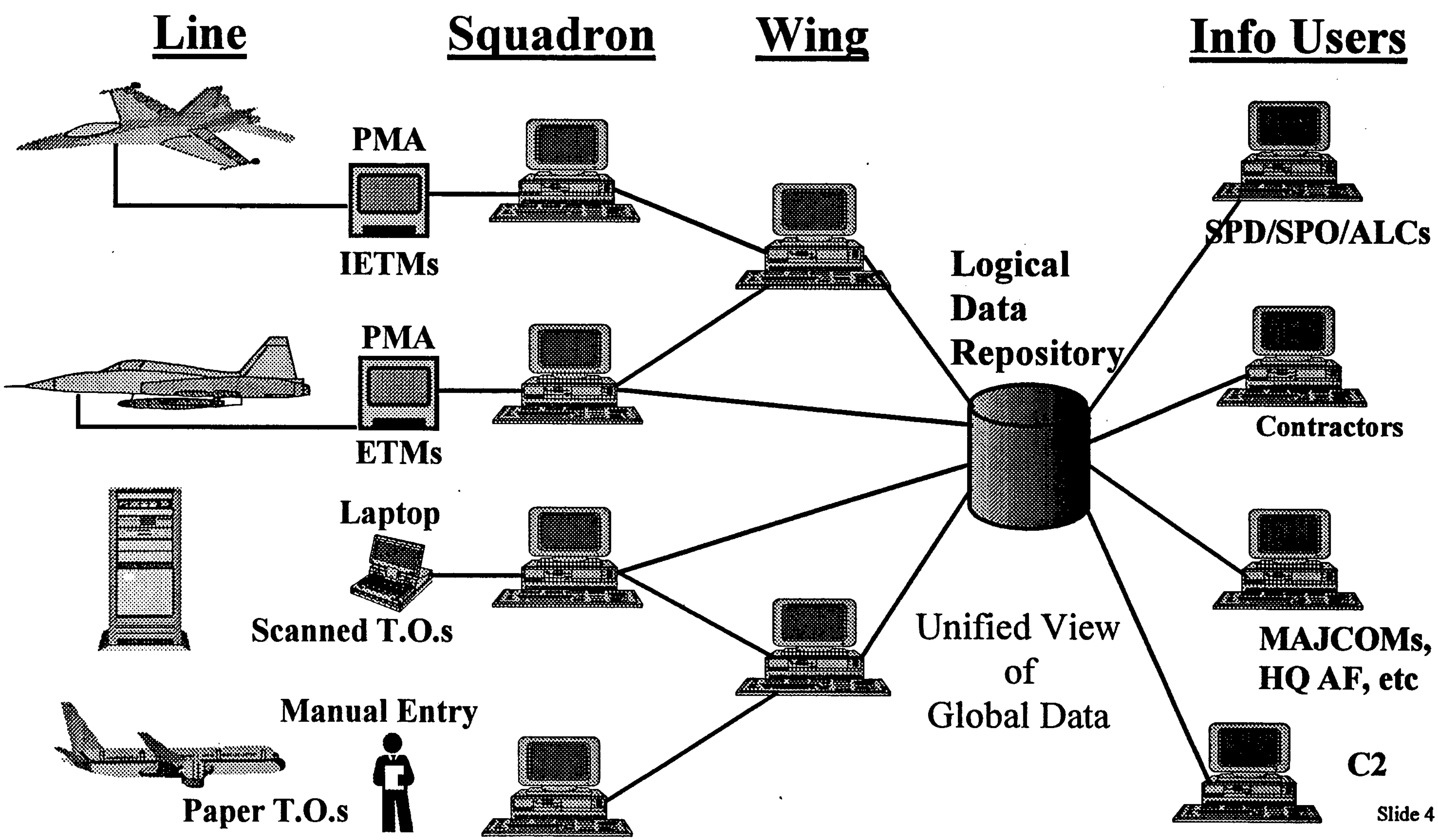
Increments developed as customer refines out-year requirements (Six increments planned)

Flexibility to incorporate advances in technology throughout program life

Leverages Commercial Off the Shelf (COTS) software and commercial practices

What is IMDS ?

Target Architecture
(Global view)



Slide 4

What is the plan?

Increments of Capability

- A Definition for six annual increments of capability
- Increment composition consists of:
  - System Requirements (universal to all increments)
  - Operational Requirements
  - Legacy System Integration
- First three increments focus on Production Mgmt and Data Collection
- Last three focus on Integrated Weapon System Mgmt
  - Total Asset Visibility

System Requirements

Requirements are universal and are applicable to all increments

- Ease of use for all levels of experience
- Deployability
- Passive & Single Data entry
- System Responsiveness
- Security
- Training
- Support
- Documentation
- Reliability & Availability

Increment One

REMIS/TICARRS

- Migrate TICARRS functionality, interfaces, and database to IMDS
- Shut down existing TICARRS
- Combined REMIS and TICARRS functionality becomes the initial part of the IMDS database and interface capability

CAMS-Base level maintenance users for aircraft and C-E

- IMDS provides the GUI and functionality for MDD to include:
  - Debrief, scheduled maintenance, Workorders, Parts Ordering, and Equipment status
- Portable Maintenance Aid Capability
  - Automated and manual data collection
  - Interface with: IETM, Diagnostics, and Equipment

Increment Two

REMIS

- As a minimum, IMDS provides GUI front end

CAMS

- As a minimum, IMDS provides GUI front end to existing CAMS functionality not included in increment one

Database Federation of REMIS with the IMDS evolving Logical Data Repository (LDR)

What is the plan?

Notional Increment Three

- Provide two-way interface between IMDS and G081
- Subsume IMIS technologies (less aircraft specific functionalities), Comprehensive Engine Mgmt System (CEMS), Tactical Missile Reporting System (TMRS), and Weapons Load Crew Mgmt System (WLCMP) into IMDS
- Continue to develop CAMS Production Mgmt functionality into IMDS
  - Personnel Management
  - Training
- Interface to Command and Control Systems
- Extend Automated WorkFlow Manager for maintenance process

What is the plan?

Notional Increment Four

- Develop REMIS applications into IMDS
- Develop remaining CAMS functionality into IMDS
  - Shut down specific CAMS host machines
- Provide Integrated Weapon System Management Functionality
  - System Performance and Analysis
  - Equipment Status and Utilization
  - Configuration Management Information
  - Quality Management Analysis
- Subsume Avionics Two-Level Information System (ATLIS), Stratotanker Condition Analysis Logistics Evaluation (SCALE), Quality Assurance Tracking and Tracking (QANTTAS), and Material Deficiency Reports Expert Analysis System (MDREAS)

What is the plan?

Notional Increment Five

- Continue Providing IWSM Functionality at all Echelons
  - Data Aggregation to Support “Fleet” Analysis
  - Inventory Management
  - Configuration Management
  - Equipment Utilization
- Provide Enterprise Visibility into maintenance process
- Begin “Wholesale” Logistics Integration

What is the plan?

Notional Increment Five (cont'd)

- **Transition Support Functions to GCSS-AF**
  - Training
  - Personnel Management
- **Provide Seamless Interoperation with Base Support Functions**
  - Supply
  - Finance
  - Personnel
- **Shut Down the final CAMS system (G054)**

What is the plan?

Notional Increment Six

- Integrate with F-22 IMIS
- Subsume G081
- Incorporate Armstrong Lab's advanced diagnostic capabilities
- Complete "Wholesale" logistic integration

Contract Information

System Integration Contractor: Andersen Consulting, LLP

Contract value: $72.5M - Develop, field & support over 6 years

Key COTS : GOLD (Western Pacific Data Systems)

GOLD product for RAAF

Strengths: Deliver 85% of ORD functions in 2 years

Early shut down of legacy system (CAMS)

Works on wide mix of hardware

Robust training (formal, on-line & embedded)

Program Schedule

Contract Award:	July 1996
First increment delivery to test bases:	July 1997
Second increment (Core) to test bases:	July 1998
Operational Test:	July 1998
Milestone Decision:	October 1998
Begin Core fielding:	October 1998

Annual development, test, fielding cycle begins

APPENDIX F.

INTEGRATED DIAGNOSTICS FOR JAST

Mr. Gary Smith

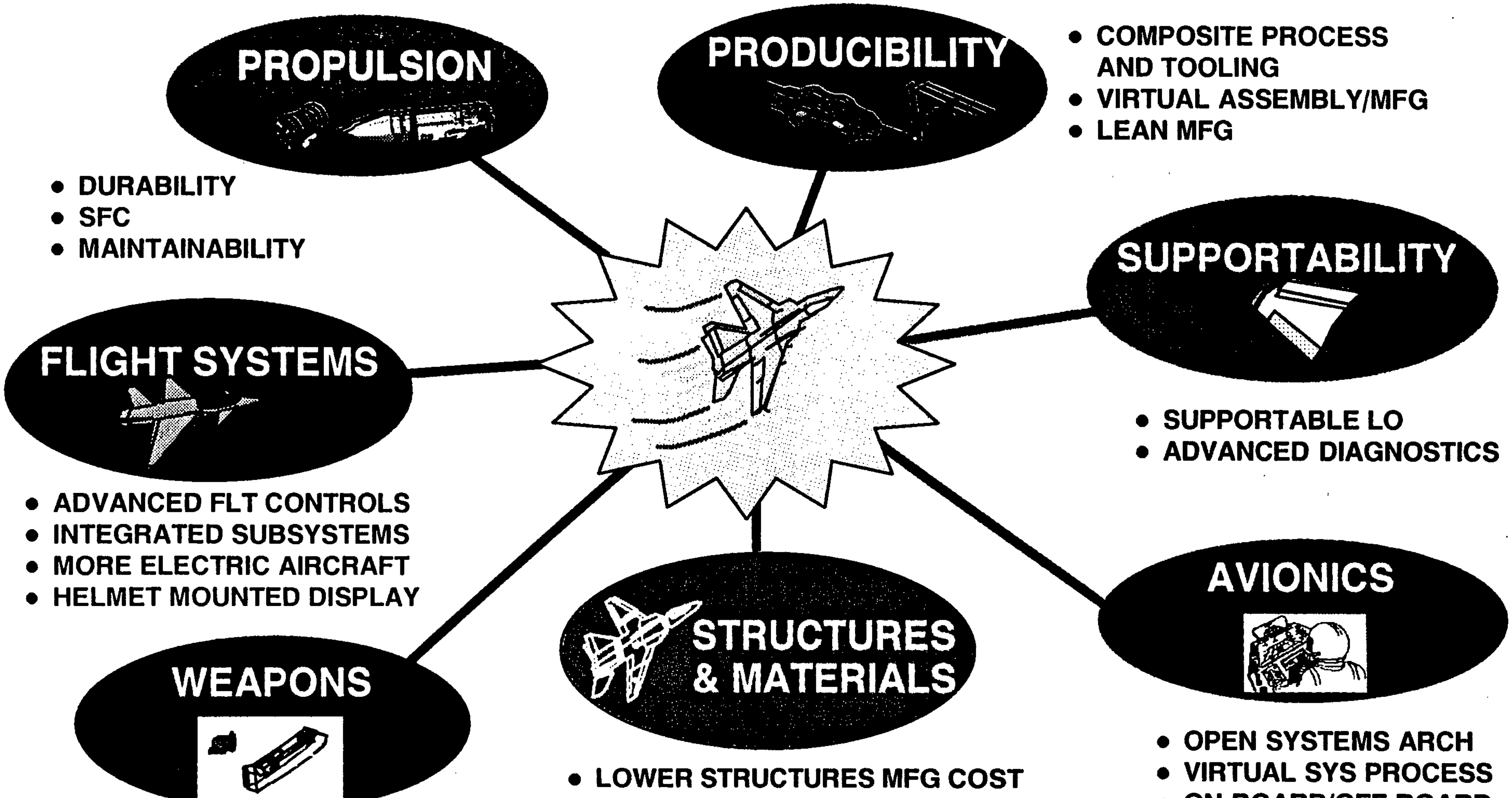
JOINT ADVANCED STRIKE TECHNOLOGY PROGRAM
U.S. NAVY U.S. MARINE CORPS U.S. AIR FORCE

Integrated Diagnostics for JAST

LOCKHEED MARTIN MCDONNELL DOUGLAS TRW NORTHROP GRUMMAN BOEING

Pratt & Whitney UDRI UNIVERSITY of DAYTON RESEARCH INSTITUTE General Electric

TECHNOLOGY DEMONSTRATION PROCESS



PROPULSION
- DURABILITY
- SFC
- MAINTAINABILITY

PRODUCIBILITY
- COMPOSITE PROCESS AND TOOLING
- VIRTUAL ASSEMBLY/MFG
- LEAN MFG

SUPPORTABILITY
- SUPPORTABLE LO
- ADVANCED DIAGNOSTICS

FLIGHT SYSTEMS
- ADVANCED FLT CONTROLS
- INTEGRATED SUBSYSTEMS
- MORE ELECTRIC AIRCRAFT
- HELMET MOUNTED DISPLAY

WEAPONS
- LO WEAPONS CARRIAGE
- LOWER COST WPNS INTEGRATION

STRUCTURES & MATERIALS
- LOWER STRUCTURES MFG COST
- UNITIZED COMPOSITES STRUCTURE
- COMMONALITY & MODULARITY

AVIONICS
- OPEN SYSTEMS ARCH
- VIRTUAL SYS PROCESS
- ON-BOARD/OFF-BOARD
- ADA-9X BENEFITS

TECHNOLOGY SUPPORTS AFFORDABILITY

TECHNOLOGY MATURATION RESULTS

- PROPULSION
  - ENGINE COMMONALITY IS IMPORTANT TO REDUCING LCC
  - ADVANCED ENGINE TECHNOLOGIES ALLOW FOR SIGNIFICANTLY IMPROVED RELIABILITY
- WEAPONS INTEGRATION
  - EXTERNAL CARRIAGE DOES NOT MEET REDUCED SIGNATURE NEEDS FOR FIRST DAY SURVIVABILITY
  - GREATER PRECISION ENABLES SMALLER WEAPON LOADS, SMALLER AIRCRAFT AND THEREFORE LOWER LCC
- AVIONICS
  - ADVANCED TECHNOLOGY OPEN SYSTEM AVIONICS CAN REDUCE LCC 8% -12%
  - EXPLOITATION OF OFF-BOARD ASSETS CAN REDUCE LCC 4% - 11% AND ENABLE ACQUISITION OF SHORT DWELL TARGETS

TECHNOLOGY MATURATION RESULTS (Cont'd 2)

- **SUPPORTABILITY**
  - ADVANCED DIAGNOSTICS CAN REDUCE SPARES UP TO 40% AND MAINTENANCE MAN-HOURS UP TO 25%
  - LO IS A MAINTENANCE MAN-HOUR DRIVER

- **STRUCTURES & MATERIALS**
  - COMMON AIRFRAME PRODUCTION LINE CAN SUBSTANTIALLY REDUCE PROCUREMENT COSTS
  - UNITIZED COMPOSITES PROVIDE IMPROVED STRUCTURAL EFFICIENCY AND ENABLE A MORE COMMON STRUCTURE REDUCING WEIGHT BY 20% AND PROCUREMENT COST BY 30%

TECHNOLOGY MATURATION RESULTS (Cont'd 3)

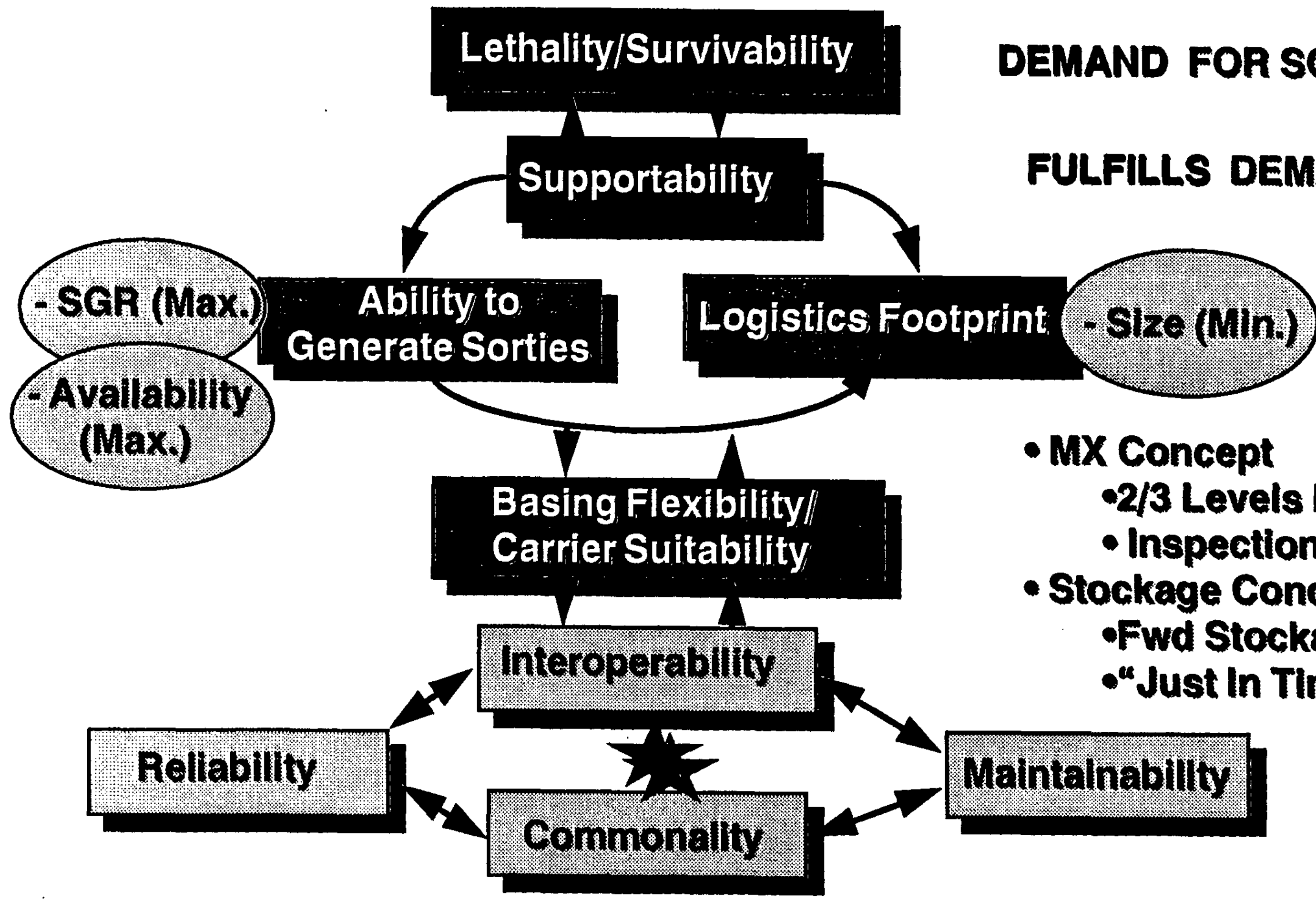
- FLIGHT SYSTEMS
  - TAILLESS CONFIGURATIONS IMPROVE SIGNATURE, REDUCE DRAG, SAVE 5% WEIGHT AND LOWER LCC BY 2% - 4%
  - INTEGRATED SUBSYSTEMS HAVE POTENTIAL TO LOWER LCC BY 2% - 3% AND REDUCE WEIGHT BY 5%
- MANUFACTURING & PRODUCIBILITY
  - LEAN MANUFACTURING HAS POTENTIAL TO REDUCE LCC 12% - 24%
  - KEY LEVERAGING MANUFACTURING TECHNOLOGIES ARE:
    - Flexible Manufacturing
    - Advanced Tooling
    - Cellular Manufacturing
    - Virtual Manufacturing
    - Integrated Cost / Design Data Base

JSF SUPPORT CONCEPT

"COLORING OUTSIDE THE LINES"

- THE JAST SUPPORT CONCEPT-- *MORE* THAN JUST "NUMBER OF PEOPLE, EQUIPMENT, SPARES,BOMBS, BULLETS AND STUFF"...
- A *DYNAMIC* INTERACTIVE SORTIE GENERATION INFRASTRUCTURE WITH UNIQUE *PROCESSES* AND *ATTRIBUTES*....
- DEMANDS *INNOVATIVE ANALYSIS AND DESIGN* TO FULLY INTEGRATE INFRASTRUCTURE ELEMENTS TO EXPLOIT STRENGTHS AND OVERCOME WEAKNESSES

AUTONOMIC LOGISTICS-- FOUNDATION FOR JSF SUPPORT CONCEPT

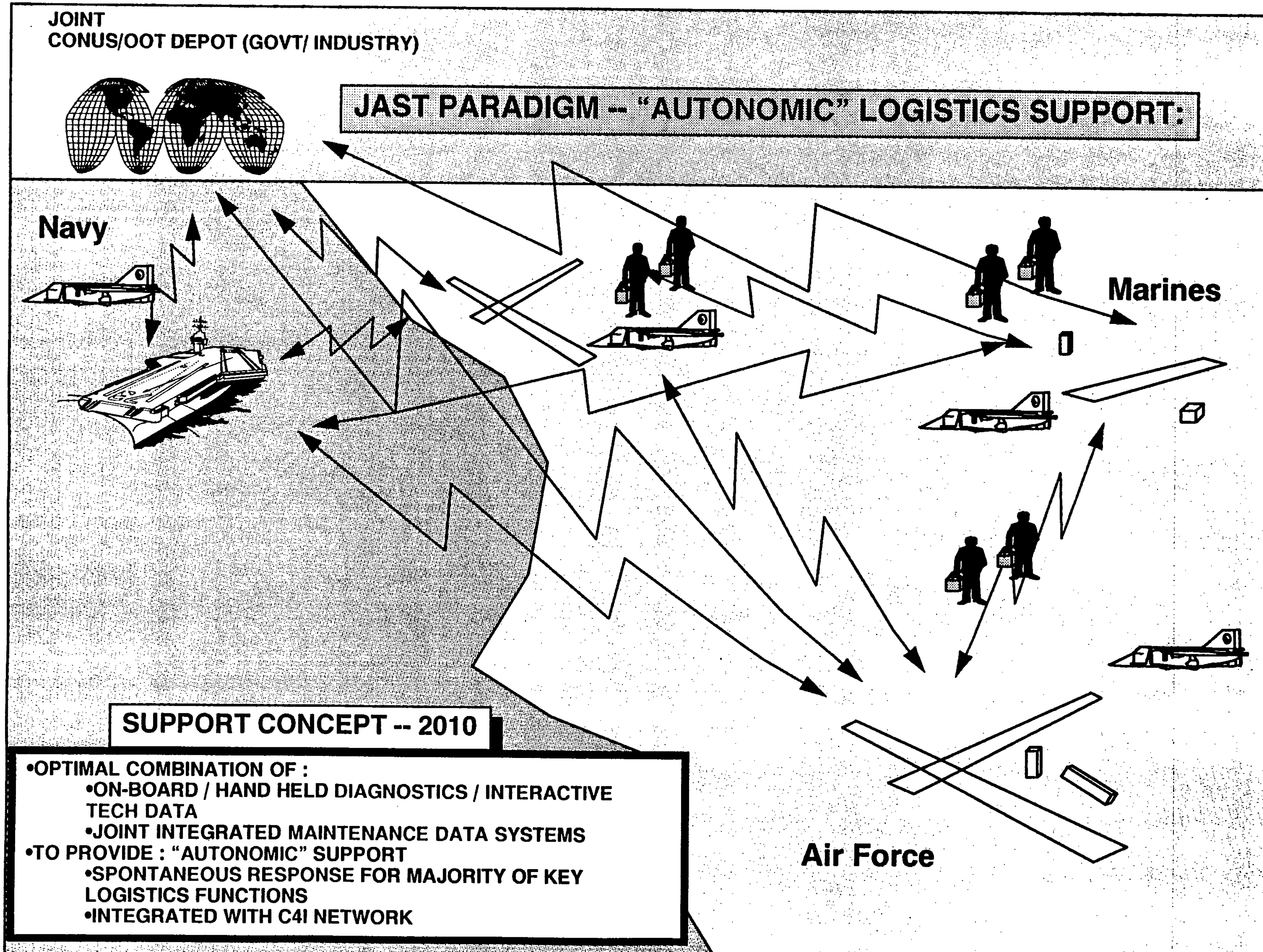


DEMAND FOR SORTIES

FULFILLS DEMAND

- **MX Concept**
  - **2/3 Levels Mx**
  - **Inspection Concept**
- **Stockage Concept**
  - **Fwd Stockage**
  - **"Just In Time"**

JAST PARADIGM -- "AUTONOMIC" LOGISTICS SUPPORT:

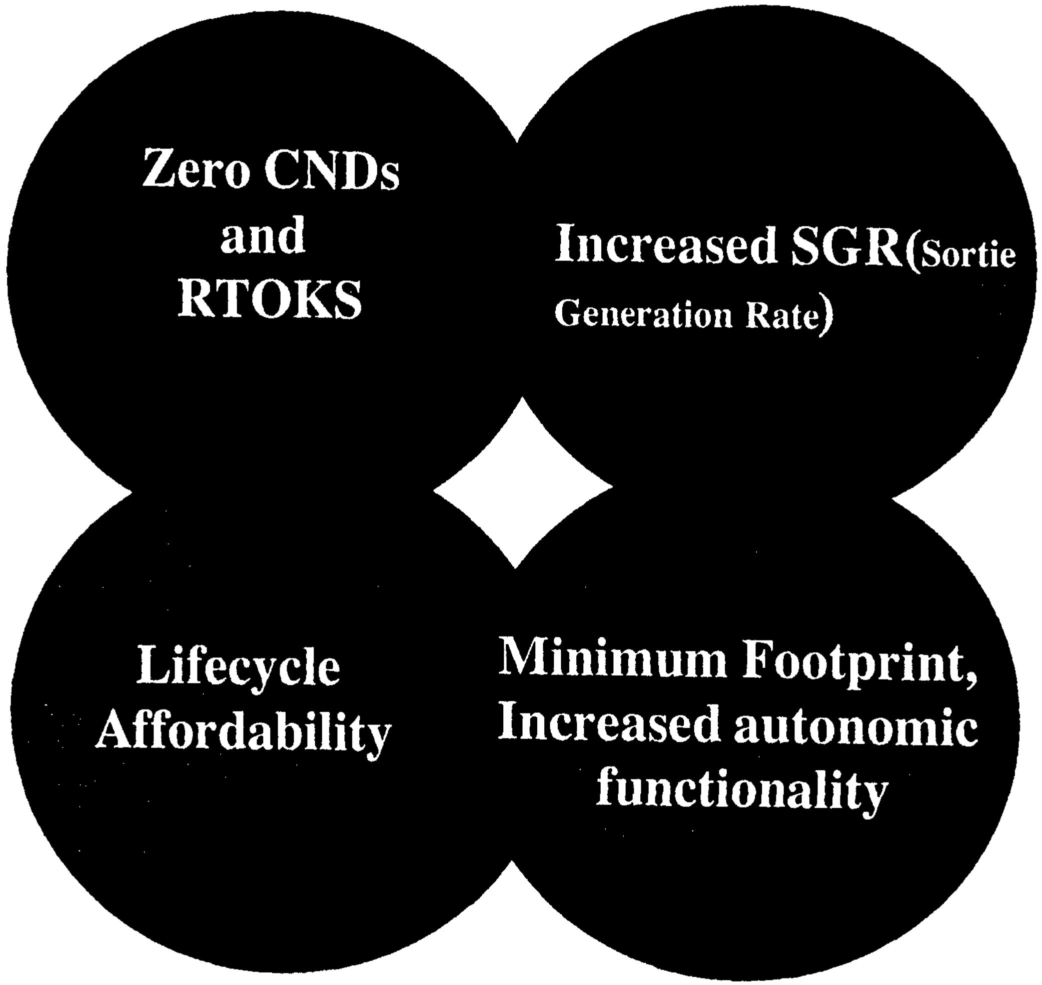


SUPPORT CONCEPT -- 2010

- OPTIMAL COMBINATION OF :
  - ON-BOARD / HAND HELD DIAGNOSTICS / INTERACTIVE TECH DATA
  - JOINT INTEGRATED MAINTENANCE DATA SYSTEMS
- TO PROVIDE : "AUTONOMIC" SUPPORT
  - SPONTANEOUS RESPONSE FOR MAJORITY OF KEY LOGISTICS FUNCTIONS
  - INTEGRATED WITH C4I NETWORK

JSF ADVANCED STRIKE INTEGRATED DIAGNOSTICS

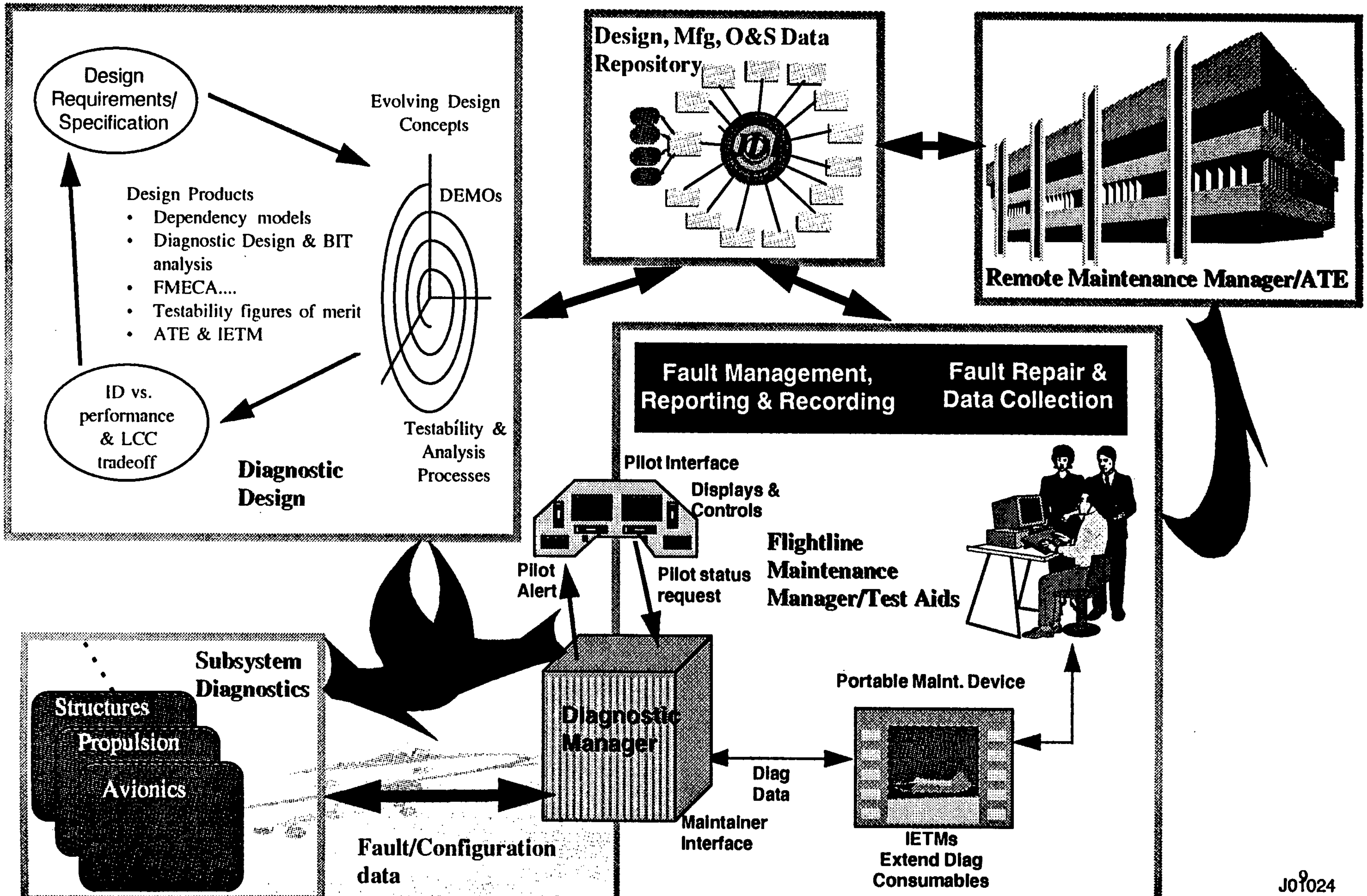
Where we want to be



Studies Indicate Integrated Diagnostics is a Major Factor in Achieving These Goals

JSF ADVANCED STRIKE INTEGRATED DIAGNOSTICS

Integrated Diagnostic Architecture/Environment Foundation



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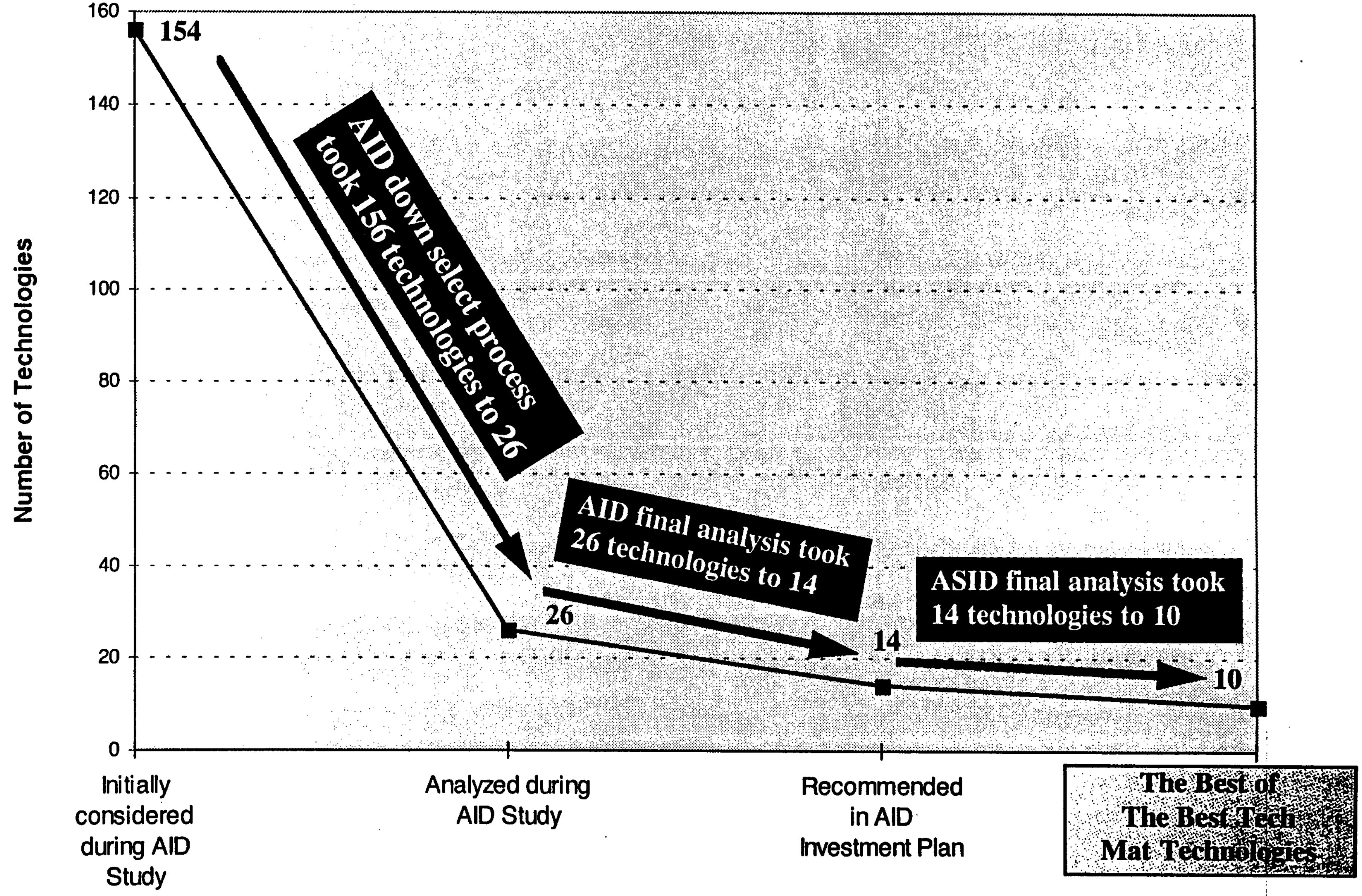
Technology Down-Selection



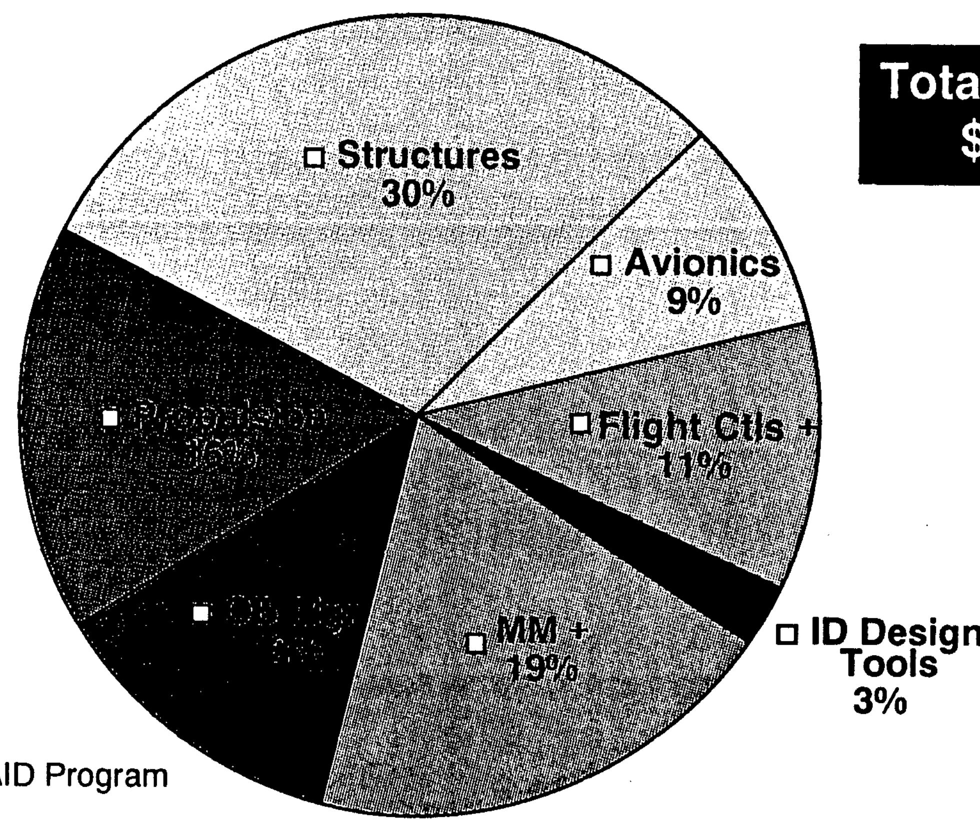
JAST ADVANCED STRIKE INTEGRATED DIAGNOSTICS

Cost-Benefit Results

TRW

Element	JOSTE LCC Benefit ($M)	Additional Benefit ($M)	Enhanced ID Costs ($M)			Total LCC Element Benefit ($M)	Payback (Years)
			Dev	Acq	O & S		
Avionics	401		4	112	9	276	2
Flight Ctls +	409		5	24	20	360	2
ID Design Tools	152		11	3	16	122	6
MM +	660		11	68	45	536	2 5
OB Mgr	444		4	37	3	400	1 5
Propulsion	464	100	5	19	9	531	1 .5
Structures	1180*		11	140	63	966	1 .5
Totals	3810		51	403	165	3191	2

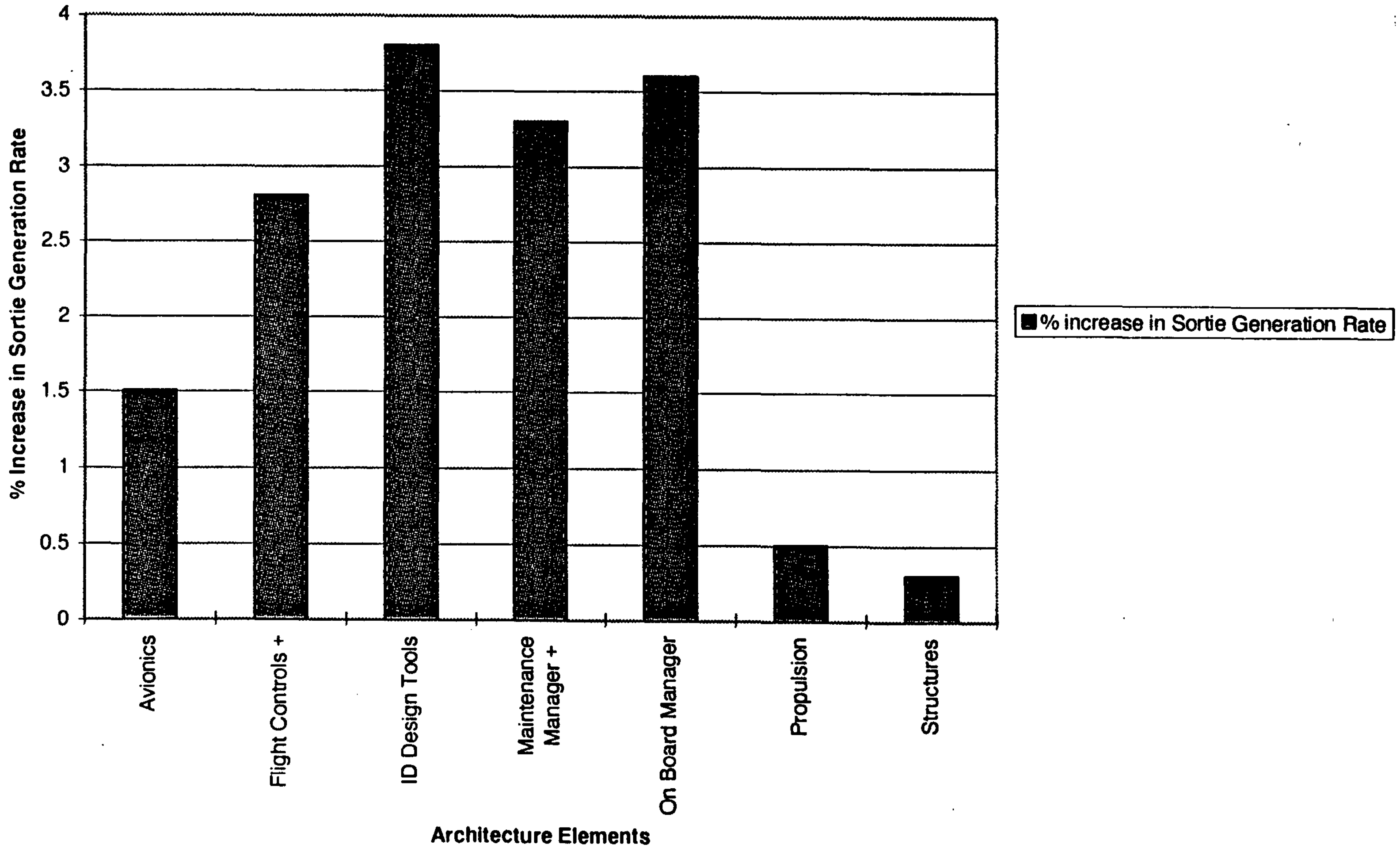
Total LCC Benefit
$3.2 Billion



* Structures Cost-Benefit from AID Program

LCOM Results

Total % Increase in Sortie Generation Rate: 6.3%



JSF

What We've Done

- Showed that an IPT can Successfully Develop an Architecture to Support Different Implementations of a Concept
- Quantified the Benefits of an Integrated Diagnostic Architecture
- Developed a Process to Evaluate an Integrated Diagnostic Architecture
- Advanced Diagnostics IPT Developed a ID Concept Plan which Identifies Maturation Effects to Ensure Low Risk Entry into EMD

JSF

What Still Needs to be Done

- Insure that Diagnostic Architecture Evolution continues through Concept Demonstration and matures through EMD and O&S
- Insure that the JSF Support Infrastructures will enable Autonomic Supportability
- Mature the Recommended ID Technologies
- Consideration of Supportability Concepts in the Requirements Generation Process

JSF

How to Ensure JSF Success

- Keep S&T Technology Development co-equal with other JSF Technologies
  - concurrent diagnostics/training/mission planning
- Infrastructure Modifications
  - Common Service Maintenance Data Collection and Processing Policies and Procedures
- Design in hooks to enable maturation of Diagnostics and Overall System Design
  - Monitor Diagnostics effectiveness
  - Monitor Weapon System Design

APPENDIX G.

AIRCRAFT MAINTENANCE EVIRONMENTS

Mr. Martin Bare


Automated Maintenance
Environment
for Naval Aviation
Briefing for the Integrated Diagnostics Workshop
Martin R. Bare
AMIDD Project Manager
Naval Air Systems Command AIR-3.6.1.2
(703) 604-3090 x4182 baremr.jfk@navair.navy.mil

OVERVIEW

- *AVIATION MAINTENANCE TODAY*
- *AMIDD PROJECT*
- *OMA NALCOMIS/AMIDD SOLUTION*
- *AME - THE NEXT STEP*
- *AME PROJECT TEAM*
- *BENEFITS*

TODAY


Upline FIRAMS
via Data Link
DSU
BIT
Data
ECAMS
AV-3M / NALDA
UPLINE
ATIS
CD-ROM &
PAPER
MANUALS
CASS

Initiative - AMIDD

Aviation Maintenance Integrated Diagnostic Demo

Description:
- Develop & Demo off-aircraft diagnostic technology
- Integrate diagnostics & interactive electronic TMs
- Improve maintenance data collection
- Improve maintenance technician troubleshooting
- Make acft condition data available for sqdn analysis
- Integrate onto NALCOMIS OMA infrastructure

Benefits:
- Reduce diagnostic time and A799 rate
- Reduce total maintenance man-hours per flight hour
- Improve sqdn decision making
- Build on existing maintenance MIS infrastructure

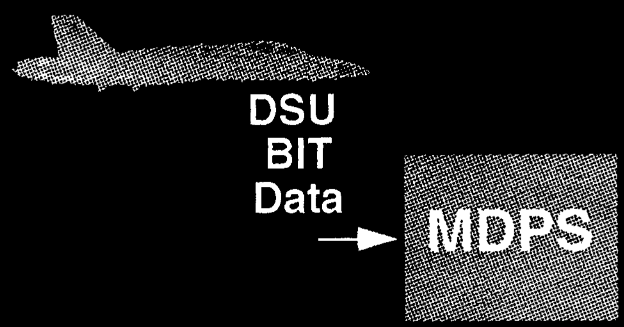
Schedule:
- Phase I - Initial development FY90 - FY92 $6M (A-12)
- Phase II - Detailed development FY93 - FY 95 $9.5M
- Phase III - 9 month test at VMFAT-101 FY95/6 $3.75M

Funding:
- OASD(ES)

Project Lead:
- NAVAIR 3.6

NAVAIR

NALCOMIS/AMIDD/MDPS INTEGRATED SOLUTION



AUTOMATED MAINTENANCE ENVIRONMENT

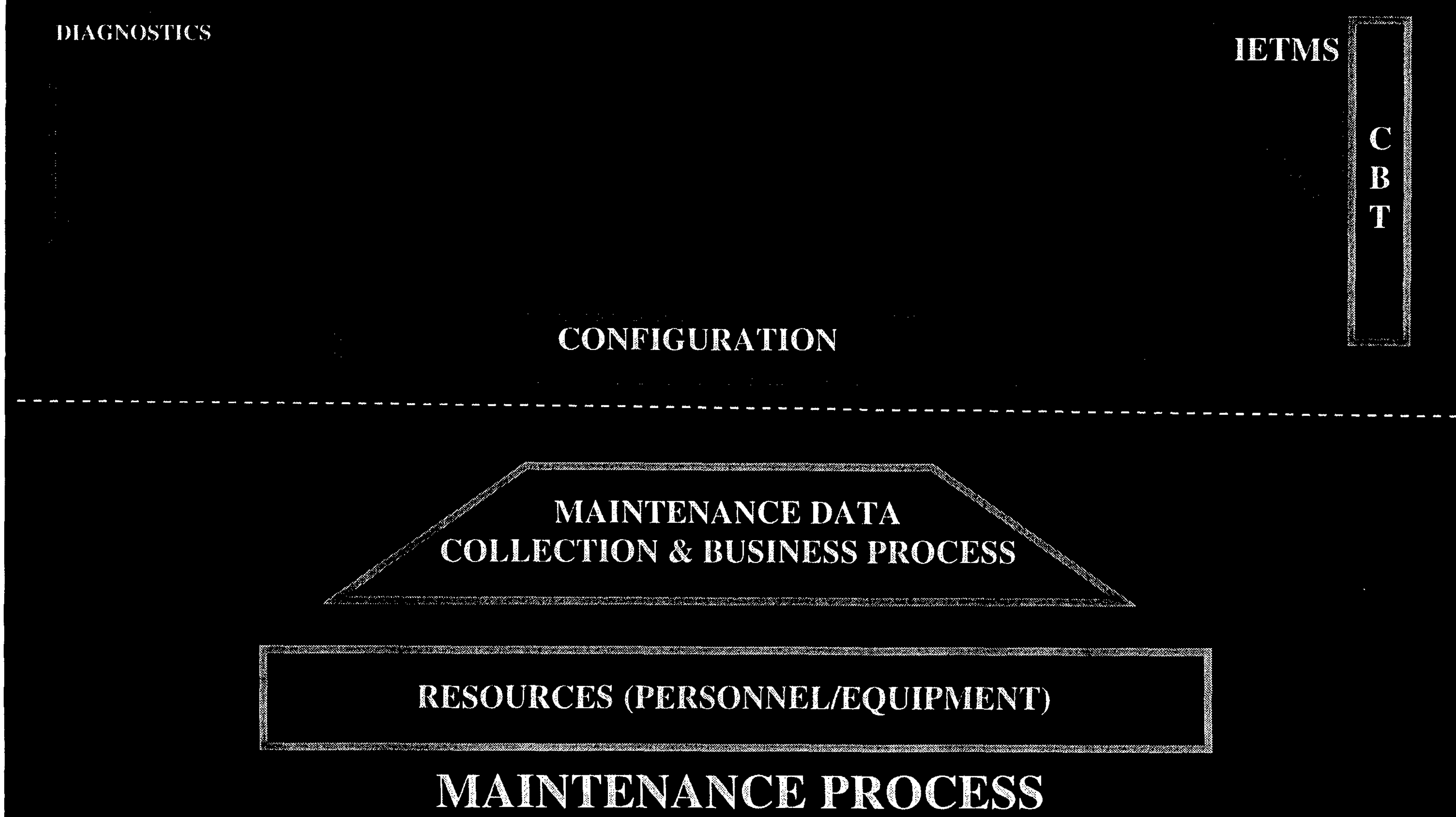
- AMIDD/NALCOMIS INTEGRATION PROVIDES ACHIEVABLE
  - AUTOMATED MAINTENANCE ENVIRONMENT
    - CLASS IV/V IETMS
    - DIAGNOSTICS
    - PROGNOSTICS
    - A/C BIT DATA INPUT TO "I" LEVEL REPAIR

    UPLINE DATA TO LOGISTICS INFORMATION INFRASTRUCTURE

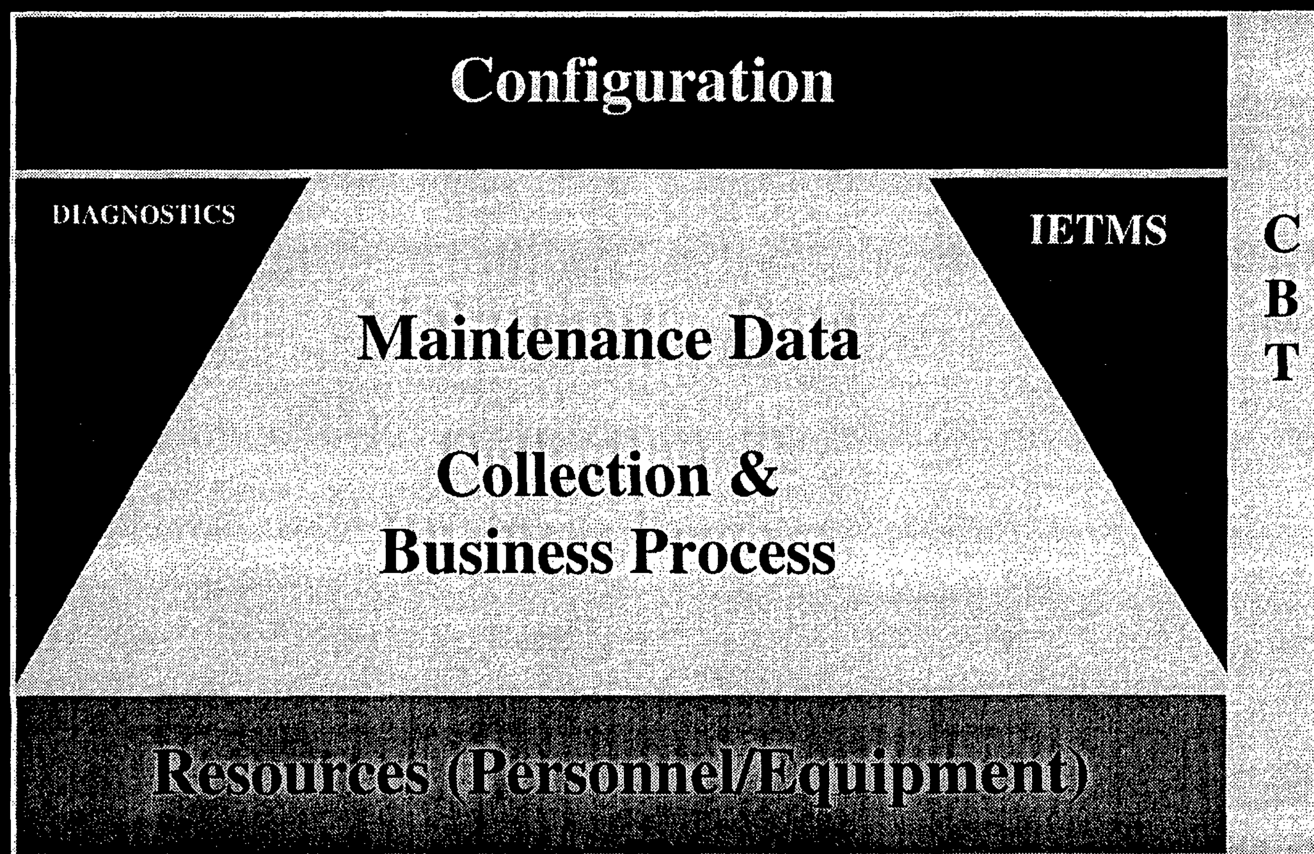
- SIGNIFICANT FLEET LEVEL BENEFITS
  - FEWER MAINTENANCE MAN HOURS/FLIGHT HOUR
  - FEWER FALSE REMOVALS
  - REDUCED AIRCRAFT TURN-AROUND

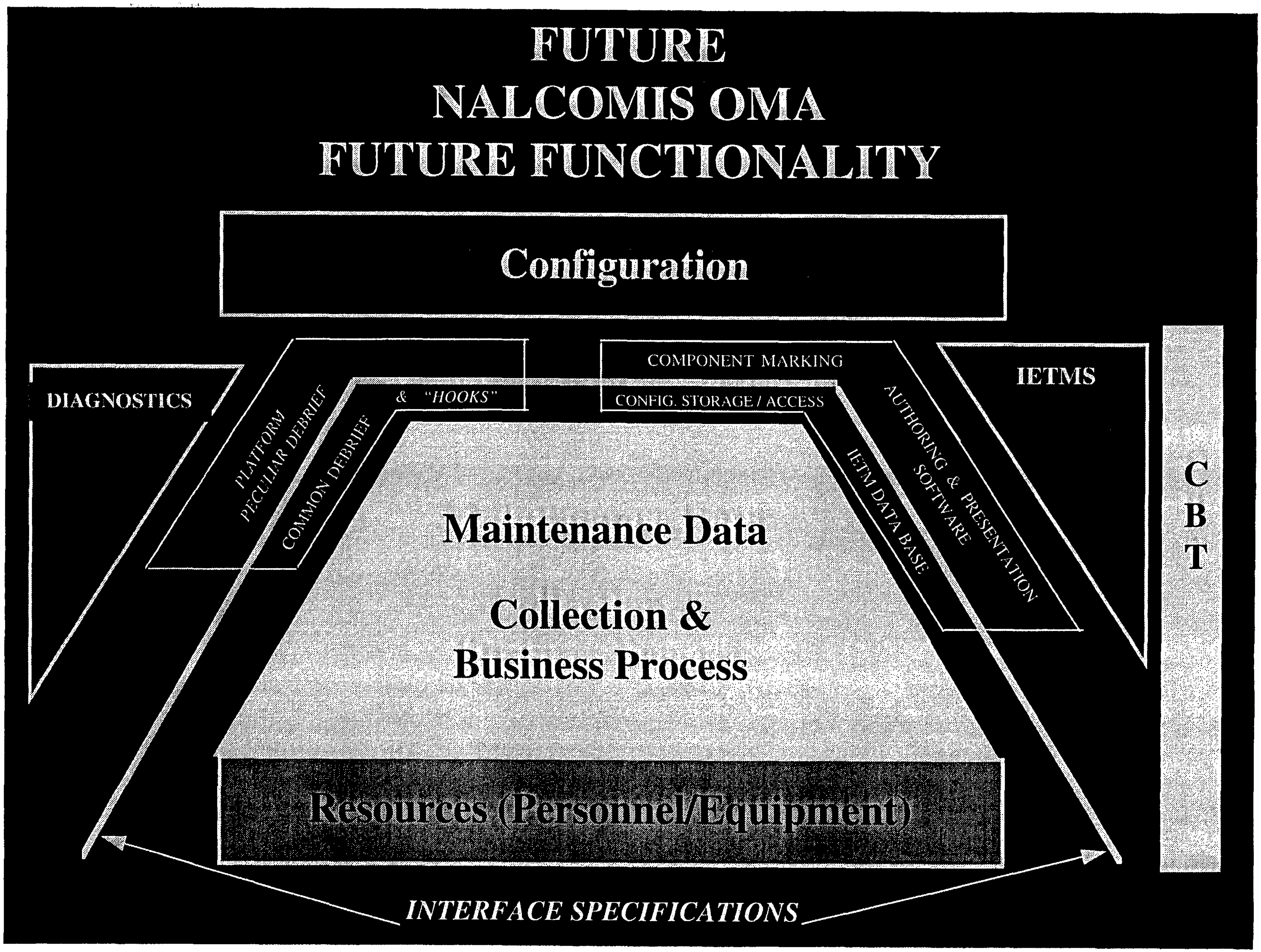
HOWEVER, THERE IS MORE TO DO

TECHNOLOGY INSERTION PLATFORM UNIQUE

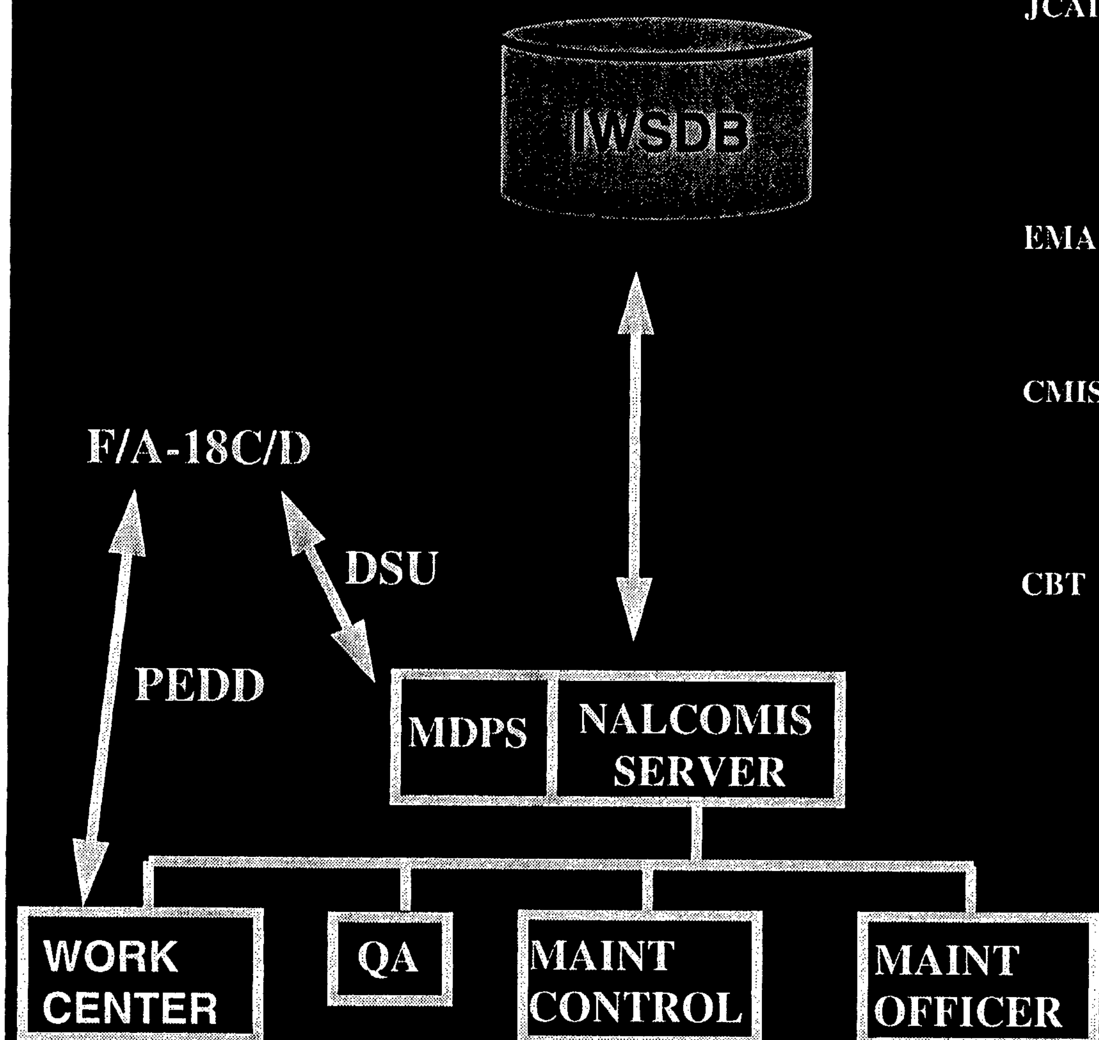


FUTURE NALCOMIS FUNCTIONALITY




FUTURE
NALCOMIS OMA
FUTURE FUNCTIONALITY
Configuration
DIAGNOSTICS
PLATFORM PECULIAR DEBRIEF
COMMON DEBRIEF
& "HOOKS"
COMPONENT MARKING
CONFIG. STORAGE / ACCESS
IETM DATA BASE
AUTHORING & PRESENTATION SOFTWARE
IETMS
C B T
Maintenance Data
Collection &
Business Process
Resources (Personnel/Equipment)
INTERFACE SPECIFICATIONS

TARGET

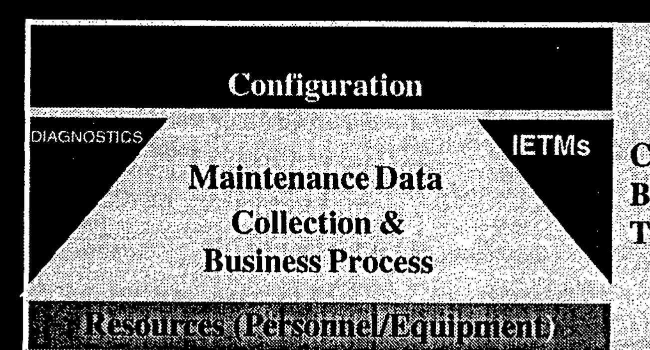


JCALS - TECH MANUALS/DRAWINGS
-WORKFLOW MANAGER
ECP
EI
TPDR

EMAIL FOLDERS
-RCM DATA ELEMENTS
-LIFE LIMITED COMPONENT AGE

CMIS - CONFIGURATION DATA
"AS-IS"
"TO-BE"
"EFFECTIVITY"

CBT -TRAINING PACKAGE UPDATES



AMIDD → AMEPILOT

Schedule:	Ends 30 June 96
Investment:	OSD $13.45 M
	A-12 $5.97 M
	F/A-18 $.25 M
	Total = $19.67 M
Results:	*Provide MNS, ORD + FEA for graphical user interface + client/server NALCOMIS OMA
	*Proved a 60% reduction in I-Level A-799 on APG-G5 Radar
	*Demonstrated means to mature BIT
	*Recovered 84% of actual A/C FLE data hours per flight hour
	*Developed IETM authoring tool + authored and used ~4500 units of F/A-18 C+D TM as IETMs
	*Evaluated four different Portable Electronic Display Devices (PEDD) in F/A-18 FRS environment
Test Site:	VMF AT-101

AMIDD → AME PILOT — IMPLEMENTATION —

Schedule: 1 April 96 - 30 Sept 99

Investment:

NAVAIR	\$6.20 M
NTCSS	\$1.67 M
PEO	\$9.41 M
Total =	\$17.28 M

Results:

*Prove 2.5 MH per FH savings in O&I Level maintenance labor

*Prove 50% reduction in O&I Level A-799 rate

*Provide 90% of FLE directly from A/C strain data + show resulting improvement in FLE accuracy

*Mark + track up to 500 components per A/C to maintain the actual configuration of each A/C

*Use two way communication to move A/C configuration, technical directives + IETM update

*Prove infrastructure required to maintain F/A-18 E + F

Test Site: VMF AT-101, VFA-106 + VFA-125

IMPLEMENTATION

Schedule: 1 April 99 - 30 Sept 03

Investment: NTCSS $59.97 M
PEO $0.12 M per squadron every 5 yrs

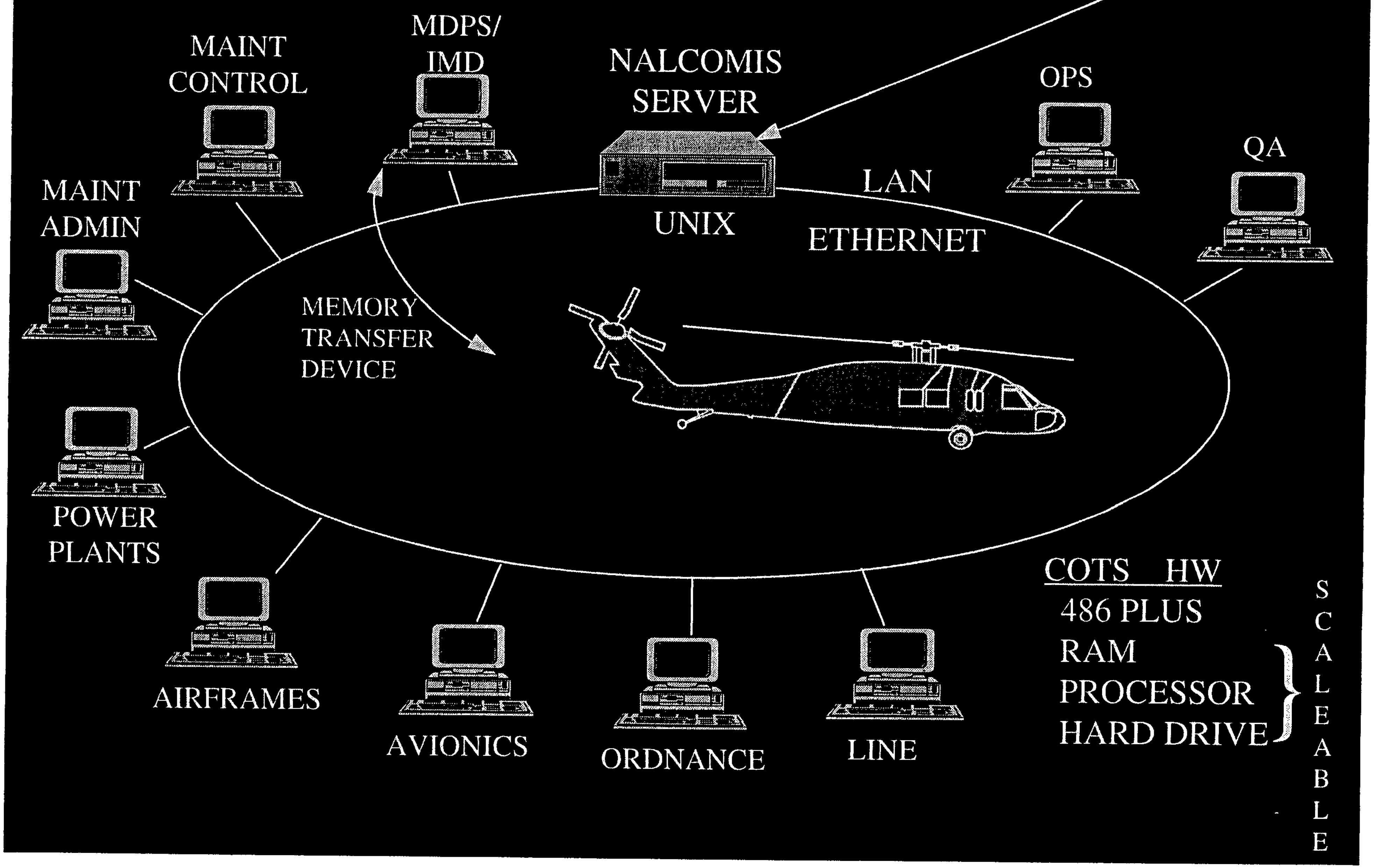
Savings:
*O&I Level maintenance - $25.2M annually
*IETM vs TM update saving - $1.03M annually
*Reductions in spares due to 50% cut in A-799 rate $10.8M annually
*Reduced cost due to longer A/C life - $3M/AC

---

*Reduce depot labor - $15M
*Infrastructure reduction - $60.1M annually
*Reduced SRC 'lost'card cost due to AIT - $19.6M

Test Site: F/A-18 C+D and E+F sqadrons

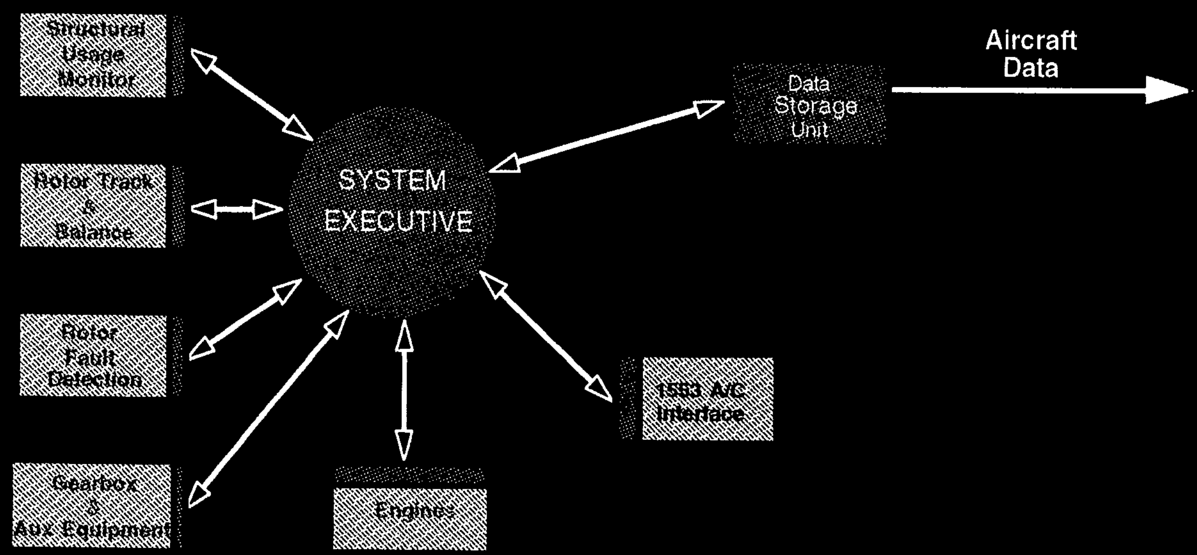
SQUADRON VIEW



AME GOALS

- PROVIDE MODERN, FLEXIBLE INFORMATION SYSTEM INFRASTRUCTURE FOR AVIATION SQUADRON MAINTENANCE ENVIRONMENT
  - "PLUG AND PLAY" OF WEAPONS SYSTEM PECULIAR SOFTWARE
  - GRAPHICAL COMMON USER PRESENTATION
  - IMPROVE ACCURACY OF TACTICAL SUPPORT DATA
  - MAKE DATA MORE AVAILABLE TO FLEET USER/MANAGER
- PROVIDE DATA TO SQUADRON MAINTENANCE FOR MORE EFFICIENT ON-AIRCRAFT MAINTENANCE AND OFF-AIRCRAFT PRODUCTION MANAGEMENT
  - COLLECT/USE MAINTENANCE AND TECHNICAL DATA FROM AIRCRAFT AND UP-LINE
  - USE OF WEAPON SYSTEM PECULIAR SOFTWARE FOR DIAGNOSTICS AND PROGNOSTICS
  - REDUCE BURDEN ASSOCIATED WITH NON-INTEGRATED TECHNICAL DATA

JAHUMS Notional Model

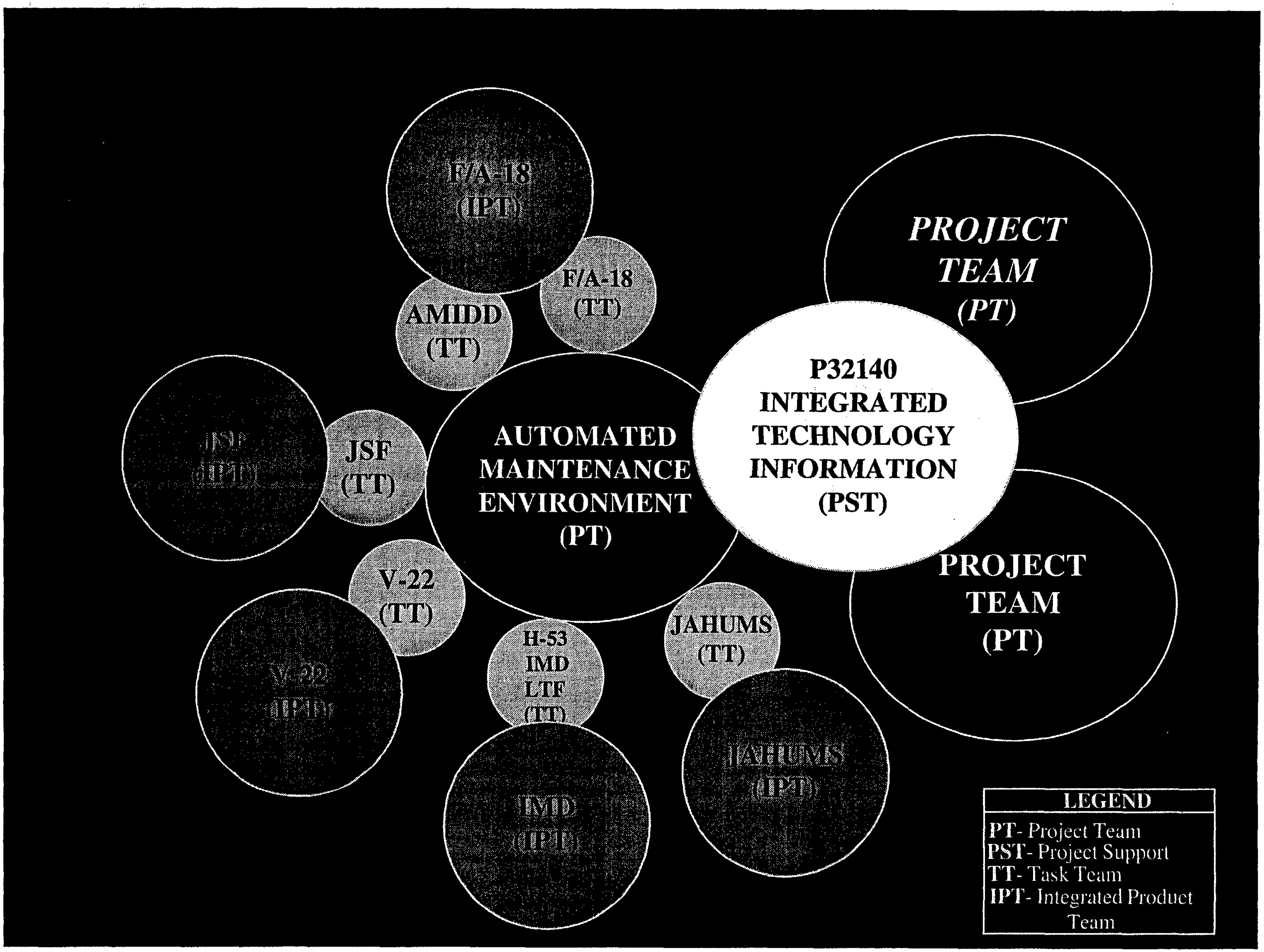


On-Board Open Architecture System

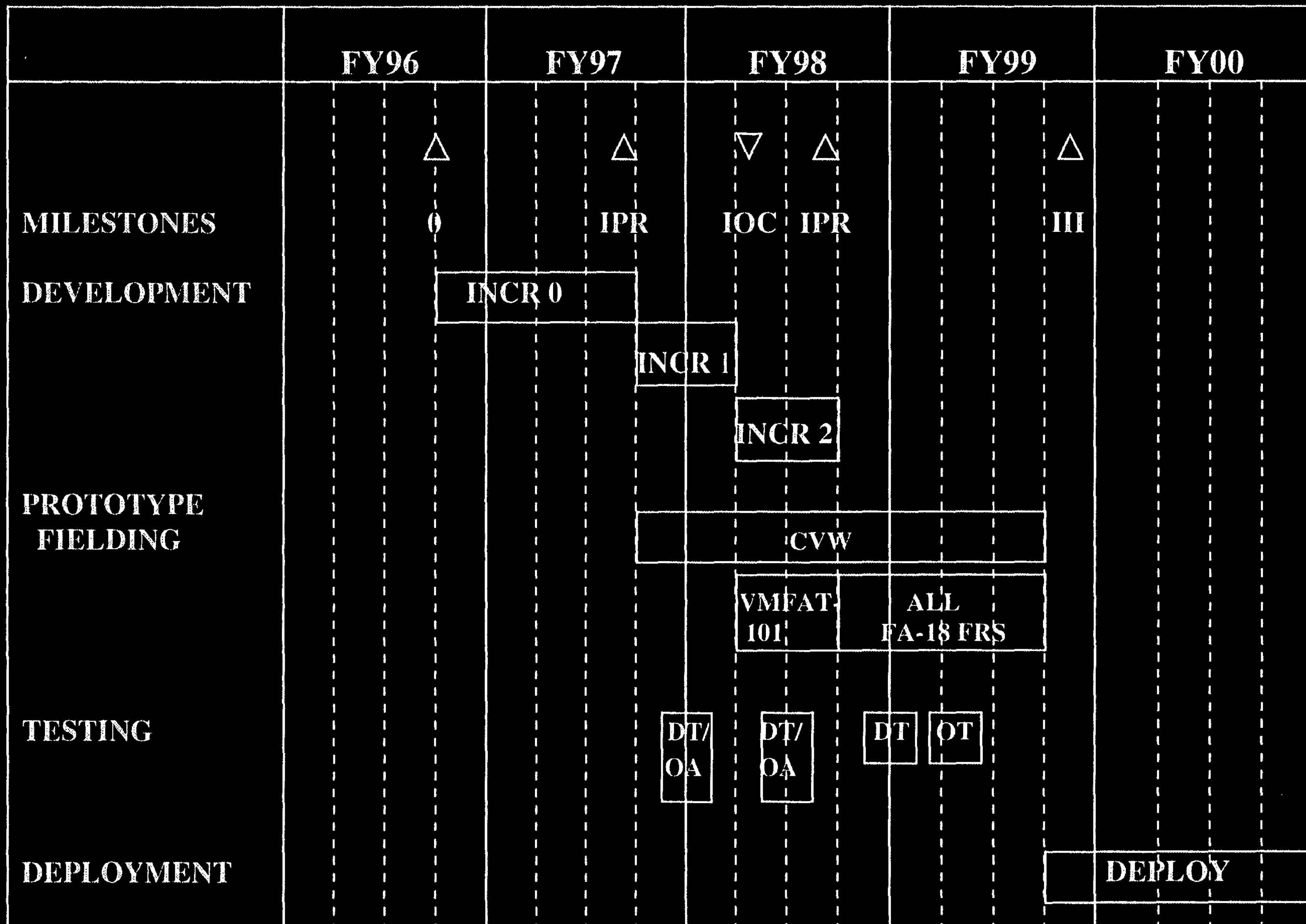
- JAHUMS Interface
- Application/Platform Specific Sensors and Processors

Off-Board Maintenance Data Infrastructure

- Existing NALCOMIS OMA System
- AMIDD Functionality


PROJECT TEAM (PT)
PROJECT TEAM (PT)
P32140 INTEGRATED TECHNOLOGY INFORMATION (PST)
AUTOMATED MAINTENANCE ENVIRONMENT (PT)
F/A-18 (IPT)
F/A-18 (TT)
AMIDD (TT)
JSF (IPT)
JSF (TT)
V-22 (TT)
V-22 (IPT)
H-53 IMD LTF (TT)
IMD (IPT)
JAHUMS (TT)
JAHUMS (IPT)
LEGEND
PT- Project Team
PST- Project Support
TT- Task Team
IPT- Integrated Product Team

AME SCHEDULE



BENEFITS

- CONTINUE TO BUILD OFF EXISTING INFRASTRUCTURE
- ACCESSIBLE “INTEGRATED” LOGISTICS SYSTEM TO IMPROVE LOGISTICS BUSINESS PROCESS
- DOWNSIZE LOGISTICS INFRASTRUCTURE WHILE MAINTAINING FLEET READINESS
- IMPLEMENTATION OF STANDARD DoD TOOLS
- ELIMINATE REDUNDANT DATA
- REDUCE LIFE CYCLE ILS/ENGINEERING COSTS
- ACHIEVE AFFORDABLE LOGISTICS WHILE MAINTAINING READINESS

GET LEANER AND SMARTER

APPENDIX H.

AUTOMATIC TEST SYSTEM RESEARCH AND DEVELOPMENT

Mr. Harry McGuckin

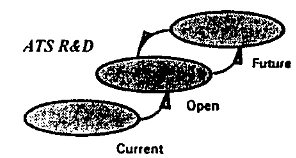
Integrated Diagnostics and the ATS R&D Project

Harry McGuckin

Chair, Joint-Service ATS R&D IPT

August 8, 1996

Outline

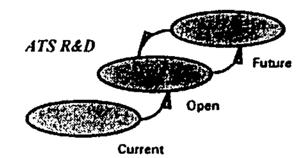


- History of the ARI
- The Need
- ATS R&D Program Goals
- ARI Organization
- ATS R&D Program Description
- ATS R&D Tasks Related to ID
- The Challenge

History of the ARI

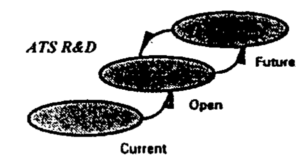
- FY91: ABET Technical Advisory Group (ATAG) formed
- FY93: Expanded to ATS Tri-Service Advisory Group (ATAG)
- FY95: ATAG expanded and refocused as ATS R&D IPT (ARI) to perform the ATS R&D Program

The Need



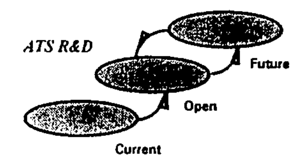
- DoD needs a lower cost process that will allow it to obtain its required test capability.

ATS R&D Program
Goals



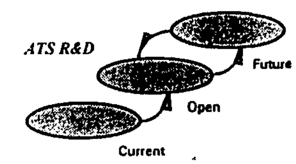
- **Hardware Commonality**
  - Reduce unique test interface hardware requirements for the next generation ATS

ATS R&D Program Goals (cont.)



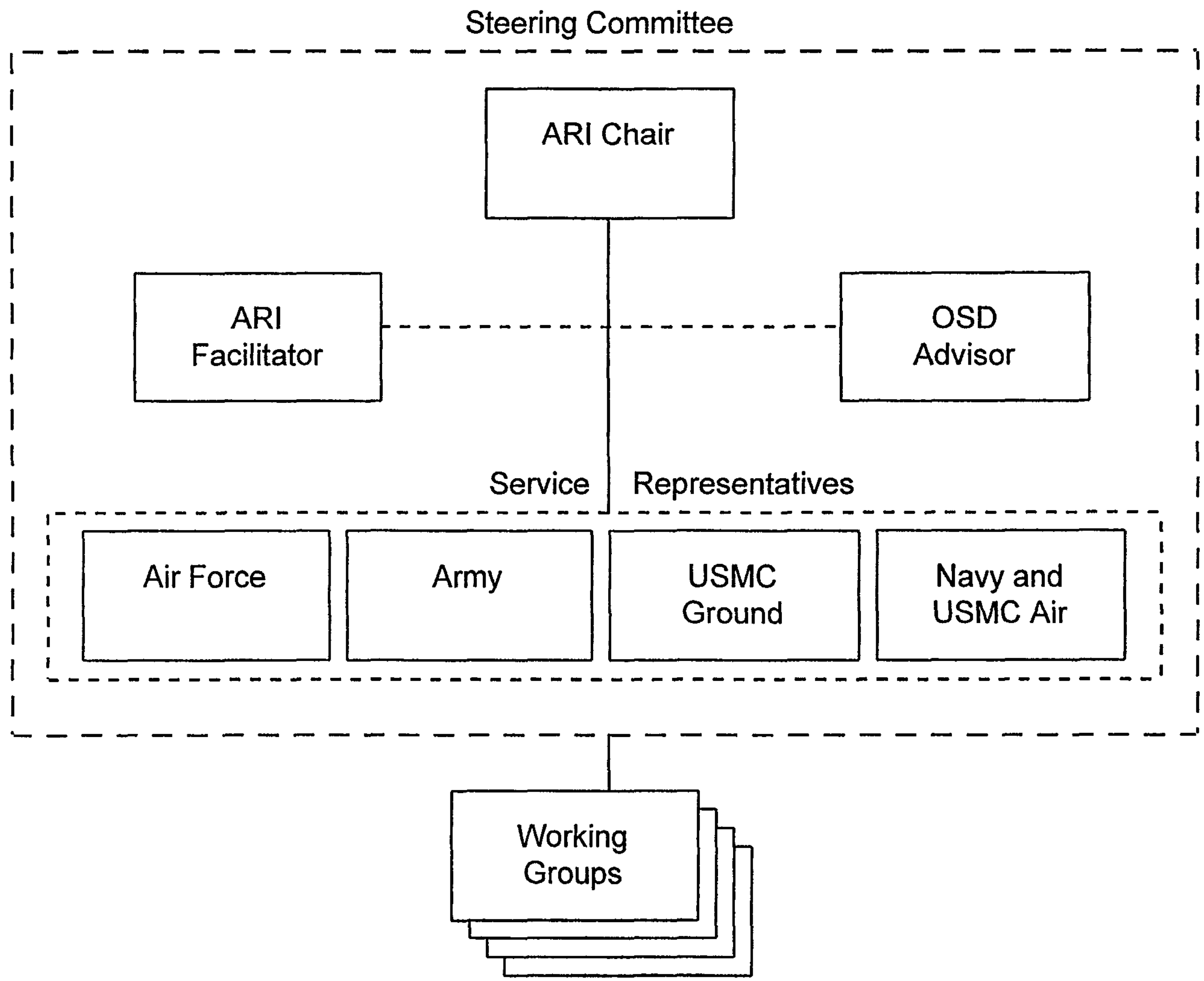
- **Software and Information Reuse**
  - Develop mechanisms for software and information reuse.
  - Develop mechanisms for increased automation in test software development.
  - Support and develop commercial standards.
  - Build commercial and DoD test libraries.

ATS R&D Program Goals (cont.)

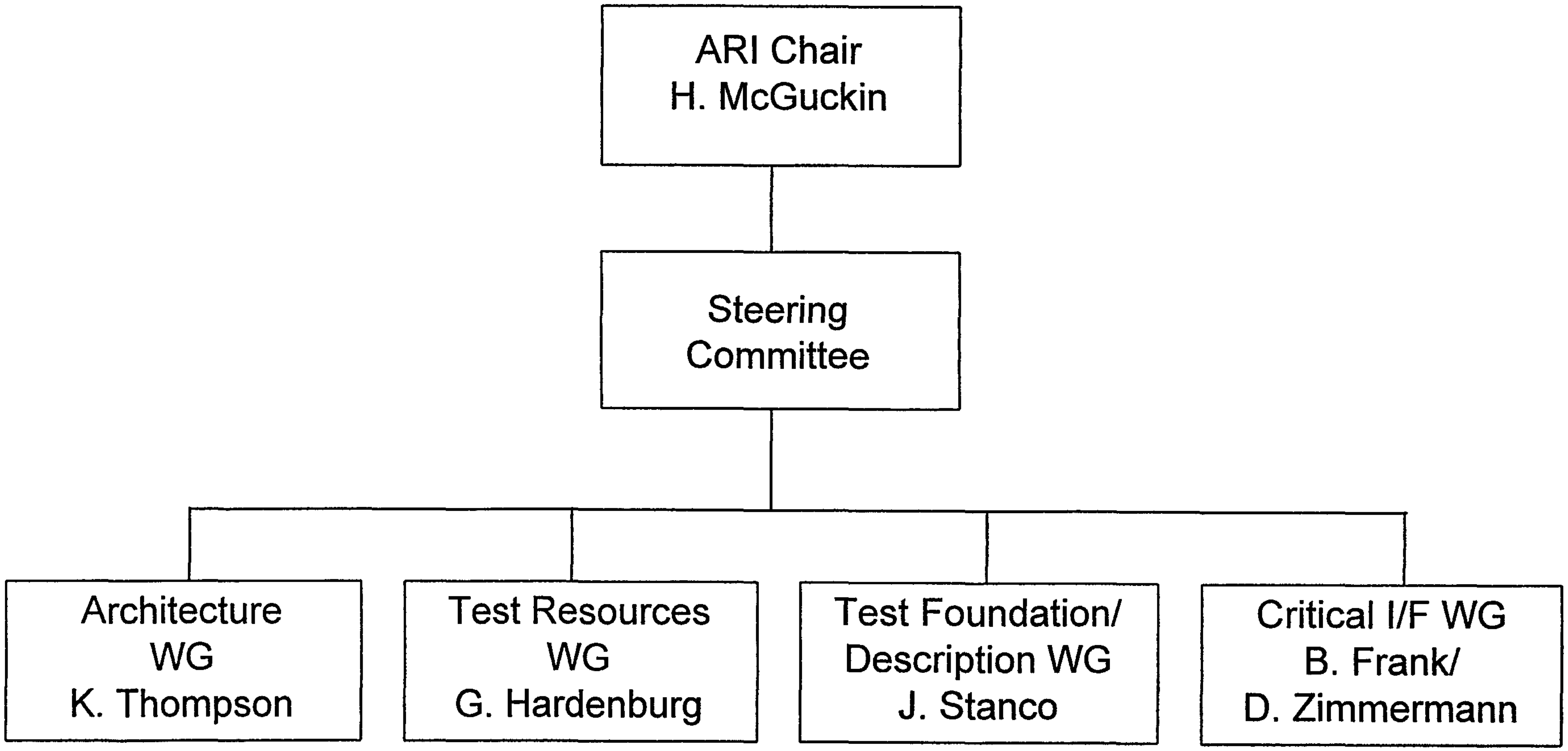


- **Process for Adaptation to New Test Requirements**
  - Build process to identify and specify test capabilities for new weapon systems.
  - Enable commercial or competitive solutions.

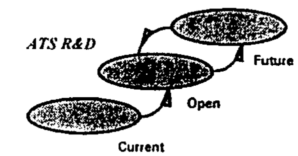
ATS R&D IPT (ARI) Organization

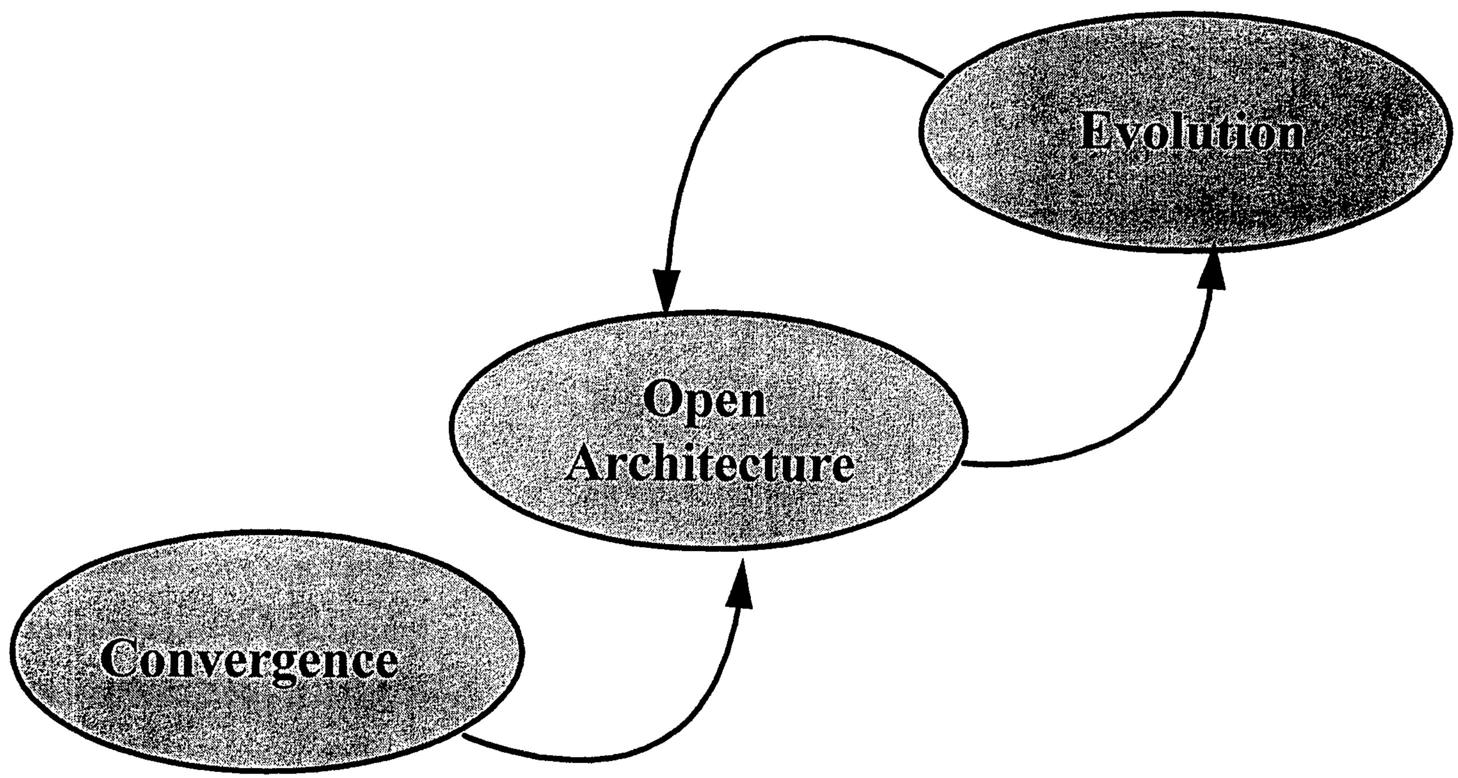


ARI Working Group Organization

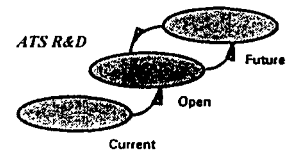


ATS R&D Program Description



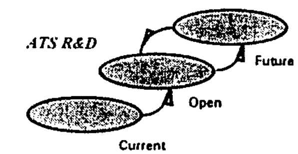


ATS R&D Tasks Related to ID



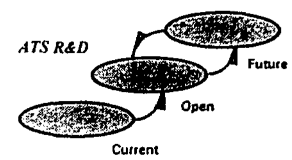
- **Task #3 - CAE Interface:** Develop information models to provide test view of product data for harmonization and coordination with CAD/CAM/CAE
- **Task #4 - Test Strategy/Test Requirements/Maintenance Data Interface:** Develop Information models for test strategies, requirements, and maintenance data

ATS R&D Tasks Related to ID (cont.)



- **Task #6 - Test Libraries:** Define and prototype library structures to support design and test integration
- **Task #7-9 - Evolution:** Develop processes/tools to capture emerging requirements in an ID environment
- **Task #11 - BIT Relationship to ATS:** Identify BIT formats and address trade-offs on-board vs off-line testing

The Challenge



- Overcoming cultural and acquisition barriers and achieving integration and information sharing
  - Throughout the weapon system lifecycle
  - Between weapon system programs and Military Services

LIST OF REFERENCES

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GLOSSARY

Automatic test system — An automatic test system (ATS) comprises three components: automatic test equipment (ATE), the stimulus and measurement instruments, operating system software, computer, power supplies, and interfaces; test program sets (TPSs), the interface devices, adapters, software programs and documentation to test individual weapon system electronic items at the box and circuit card level; and ATE/TPS software development environments, the ATE and unit under test (UUT) simulators and description languages, and programming tools.

Automatic test equipment — The stimulus and measurement instruments, operating system software, computer, power supplies, and interfaces.

Built-in test — There are two basic types of weapon system built-in test (BIT). Logic level based BIT, also identified as digital BIT, takes advantage of digital pathways to concurrently or off-line verify performance and fault isolate to a removable item. The second type of BIT is sensor and microcomputer based and can be applied across all electronic, electro-optical, and electromechanical applications [Rolfe 94, p. 186].

Data, useful — Data is useful when it (1) accurately portrays a number of status conditions (e.g., fault detection, fault isolation, fault prediction, system configuration); (2) identifies preferred action strategies (e.g., corrective procedures, diagnostic approaches, reliability enhancement options); and (3) assesses capabilities and identifies deficiencies (e.g., analyzes high-cost drivers, supports "what if" analyses, operating performance feedback, spares requirements).

Demonstration program — In the context of the workshop, the term *demonstration program* was intended to represent an activity or project with the principal goal of illustrating the feasibility and benefits of integrating diagnostics elements [Rolfe 94, p. 186].

Diagnostics elements Diagnostics is the practice of investigating the cause or nature of specific problems that inhibit normal operations. System diagnostic capability is developed and provided through engineering design, testing, technical information, and trained personnel. The *diagnostics elements* that support this capability include built-in test, automatic and manual test equipment, training, maintenance aiding, and technical information [Rolfe 94, p. 186].

Domain In the context of the workshop, the term *domain* was intended to address weapon systems and their capabilities that span from legacy systems to new and proposed weapon system designs, and included all inter-Service weapon system applications across operational boundaries such as those found in air, land, and sea system applications.

Infrastructure In the context of integrated diagnostics, the IDA study team defined *infrastructure* to represent a collection of hardware and software elements, interfaces, policies, and processes that provide the means of implementing a support capability.

Integrated diagnostics "... a structured process which maximizes the effectiveness of diagnostics by integrating the individual diagnostic elements of testability, automatic testing, manual testing, training, maintenance aiding, and technical information." [Keiner 90]

"... the term "Integrated Diagnostics" was used (1) to represent a structured design process that integrates all related pertinent diagnostics elements, (2) to represent an acquisition approach that develops and acquires various diagnostics elements as a package, and (3) to represent a deliverable system (or subsystem) that integrates diagnostic elements" [Brown 90a].

Legacy systems The workshop context was *existing systems*.

Life cycle "All phases of the system's life including research, development, test and evaluation, production, deployment (inventory), operations and support and disposal." [DOD 91, B–58]

Logistics tail The chain of logistics support that goes from the battlefield back to the continental United States maintenance depots, factories, and contractor support personnel.

Open system architecture
Provides a structured design process to integrate all relevant diagnostics elements, a performance-based acquisition approach for the delivery of diagnostics elements as a package, and mechanisms to facilitate easy integration (e.g., plug-and-play approaches) of subsystems that will improve diagnostics and maintenance. It also uses well-defined, industry standards body, or commonly accepted interfaces to interconnect, exchange data, and process information between diagnostic elements.

Problem, test or diagnostic
A condition that limited weapon system capability or performance. For the purpose of this analysis, a problem was considered critical when it was more costly to compensate for the problem causing conditions with available practices (such as manual or automatic testing, additional maintenance man-hours or training, additional spare or replacement parts, etc.) than it was to restore or achieve satisfactory performance levels with practices that would integrate the diagnostics elements.

Test program set
The interface devices, adapters, software programs and documentation to test individual weapon system electronic items at the box and circuit card level.

Weapons system
"Items that can be used directly by the armed forces to carry out combat missions and that cost more than $100,000 or for which the eventual total procurement cost is more than $10,000,000. Such term does not include commercial items sold in substantial quantities to the general public. (See Title 10, United States Code, Section 2403, 'Major weapon systems: contractor guarantees.')" [DOD 91, B–121]

LIST OF ACRONYMS

AMID	Aviation Maintenance Integrated Diagnostics
ASIS	Advanced Strike Integrated Diagnostics
ATE	Automatic Test Equipment
ATS	Automatic Test System
BIT	Built-In Test
CND	Can Not Duplicate
COTS	Commercial off the Shelf
DOD	Department of Defense
IC&A	Industrial Capabilities and Assessments
ID	Integrated Diagnostics
IDA	Institute for Defense Analyses
IEEE	Institute of Electrical and Electronics Engineer, Inc.
IMDS	Integrated Maintenance Data System
IPT	Integrated Product Team
IRB	Independent Review Board
JAST	Joint Advanced Strike Technology
MOE	Measure of Effectiveness
NSIA	National Security Industrial Association
OJT	On the Job Training
OSD	Office of Secretary of Defense
PMA	Program Management Agreement
POC	Point of Contact
PPBS	Planning, Programming, and Budgeting System
R&D	Research and Development
RTOK	Re-Test OK
SPO	System Project Office
TPS	Test Program Set
UUT	Unit Under Test

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13. ABSTRACT (Maximum 200 words)
This paper documents the activities and results of a Joint Service Integrated Diagnostics Workshop hosted by IDA on August 8, 1996, and provides an IDA study team's analyses of workshop results. Workshop participants included representatives from the technology development, acquisition, and support functional areas of the Services (Army, Air Force, Navy, and Marines). The objectives of the workshop were to increase awareness of integrated diagnostics application benefits, identify weapon system support problems where a better integrated diagnostic approach could be applied, propose cross-cutting integrated diagnostics opportunities, and begin discussions on the opportunities of applying open or non-proprietary architectures to integrated diagnostics. The IDA study team developed overall findings and observations. These, in turn, were the basis of the IDA recommendation that DOD should conduct a two-phase study and demonstration activity to establish an integrated diagnostics open system architecture. Such a recommendation stood out as possessing the greatest potential benefits.

14. SUBJECT TERMS
Integrated diagnostics, weapon systems, open system architecture, interfaces, diagnostics elements, legacy system, system life cycle.

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